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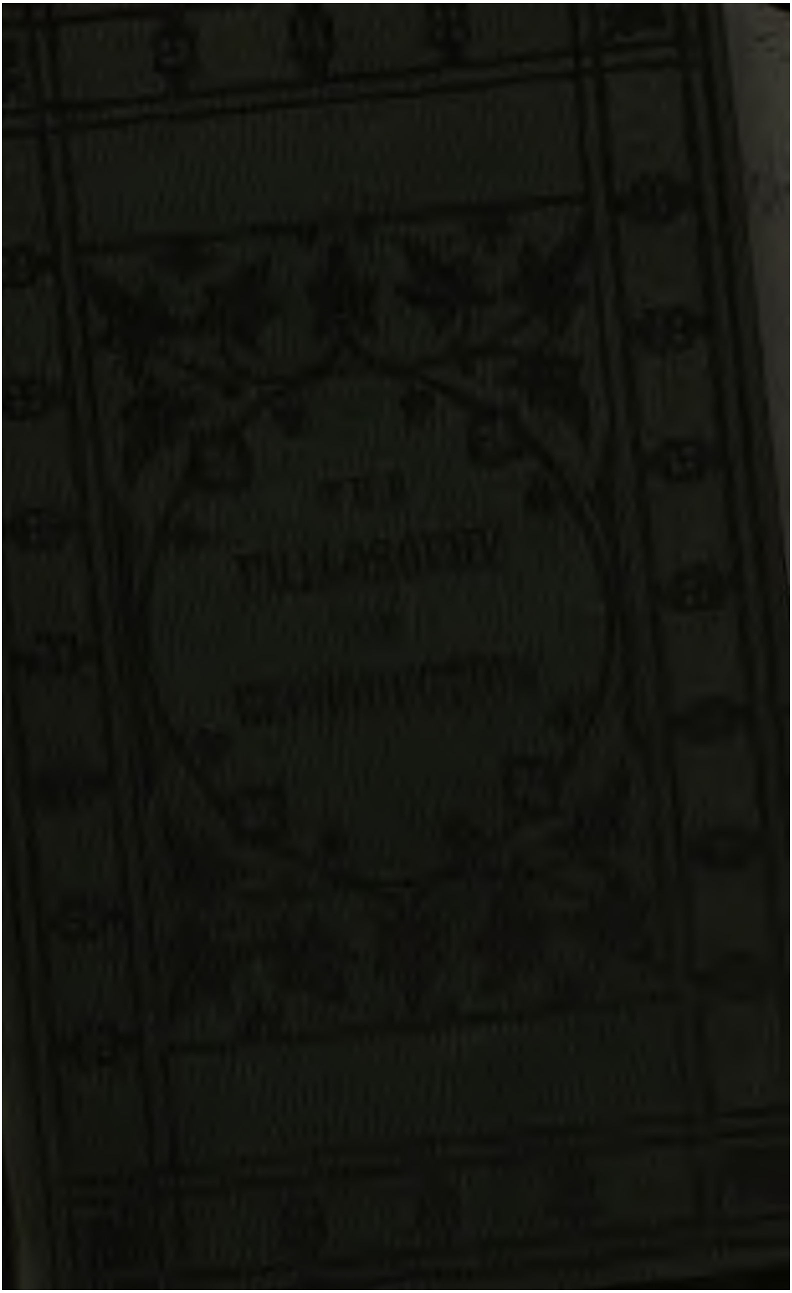

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PHILOSOPHY OF REPRODUCTION.

LONDON:
A. and G. A. SPOTTISWOODE,
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THE

PHILOSOPHY OF REPRODUCTION.

BY

ROBERT JAMES MANN, M.D. F.R.A.S.

AUTHOR OF "THE GUIDE TO THE KNOWLEDGE OF LIFE," "THE BOOK OF HEALTH,"
"LESSONS IN GENERAL KNOWLEDGE," ETC.

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PREFATORY REMARKS.

The object of the following pages is to explain familiarly such points of physiological science as could not appropriately have been noticed in the "Guide to the Knowledge of Life," just published by the Author, on account of that little work being designed for a very general circulation, and to a great extent for the use of the young. The subject is nevertheless so treated as to be adapted for the reading of all intelligent and educated persons, who wish to understand the operations of Nature in their broadest and grandest relations, and to attain sound and accurate knowledge in matters that relate to the laws and conditions of life.

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THE

PHILOSOPHY OF REPRODUCTION.

MR. Finlaison estimates the population of England for the close of the seventeenth century at about five millions and a quarter of *souls*. It is to be presumed that, in fixing this amount, he has not been hypercritical in the matter of psychological qualification, and that it may therefore be taken for granted that this number expresses the sum total of unfledged bodies which moved about upon two legs in the land of the Angles at that time. At the middle of the nineteenth century appointed enumerators found that the five millions and a quarter had become, in round numbers, eighteen millions; that, in fact, the inhabitants of England (not taking Scotland into the account) had nearly quadrupled themselves in 150 years, besides sending countless crowds to people vast lands in the West and in the South. In the year 1851 it was found that London contained within its own precincts nearly half as many inhabitants as all the island held in 1701. On one memorable day—the 9th of October, 1851—there were collected in a single hall, erected in one of its parks, a fifty-sixth part of the full complement of English people that were alive in 1701. The Registrar-General has endeavoured, in his report of the result of the recent census to furnish a definite idea as to what millions mean where population is concerned. He states that if every person living in Great Britain had only a square yard to stand upon, there would still be seven square miles of the crowd when all were collected together; or that if every individual were planted out over the surface of the island, as cabbages are planted out in the best arranged market gardens, each would be 108 yards away from his neighbours. Let the entire crowd of these animated cabbages be gathered from all the corners of the land, and be required to file through Temple Bar in a column four deep, and moving at a quick-march step, it would take three months of twelve-hour days (Sundays being allowed for rest) to get the entire living stream through; and if a single individual were to undertake to pass them through a gate, as turnpike-men do flocks of sheep, enumerating them at the rate of one every second as they went, he would be a year and a half, working twelve hours a day (exclusively of Sundays), before he finished his task. Now, it has been ascertained that this vast mass of people is at the present time occupied with doubling itself every fifty-two years and a half; so that if the same state of affairs were to continue without interruption or change until the year 2534, the inhabitants of Great Britain, instead of each having a space of 108 square yards to himself, would all touch each other by their elbows. There would be just standing room for all, but no one must think of moving. Britannia, with its eleven degrees of longitude and ten degrees of latitude, would then look from the ocean like a huge rock covered by its impenetrable crowd of penguins or boobies. Such, indeed, under these circumstances, would be the prospects of our favoured land.*

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* See a very interesting little resumé of the census of 1851, by Edward Cheshire.

These considerations are surprising enough in themselves; but there is an important fact connected with them, that greatly enhances the wonder with which they are contemplated when it is brought prominently into view. This rapid augmentation in the ranks of the population has gone on, not only in despite of a constant emigration to foreign lands (more than two millions and a half of individuals emigrated between the years 1821 and 1851), but also in the face of the yet more serious drain from the operation of the ordinary conditions of mortality. More than one thousand people died every day in England and Wales during the year 1850. Of the eleven millions who were alive in 1801, eight millions had passed to the silent tomb, before those eleven millions had multiplied into twenty-one millions in 1851. Before the twenty-one millions can become forty-two millions, which they would do by 1904, under the present rate of increase, at least thirty millions will have been swept from the earth, by either premature or natural decay. By that time nineteen millions of British subjects will also have found a foreign home, even if the rate of migration does not increase with augmenting numbers. But emigrants double their ranks in considerably less time than half a century, on account of their consisting almost exclusively of individuals included within the reproductive periods of life. Hence, the nineteen million British emigrants scattered over the world will be really more than thirty-eight millions in their new homes. If, then, the existing state of things be continued without modification for another half century, it may fairly be assumed that the twenty-one millions at present inhabiting our island will have changed themselves into a hundred millions of souls. In reality, it is known that this rate of multiplication does not take place over any large area of the earth, on account of various modifying and repressing influences that are continually at work. Thus, although the population of Great Britain nearly doubled itself in the half century that preceded 1851, there was an absolute diminution of numbers in the year 1850, if taken alone. In that year the excess of births over deaths amounted to 224,000; but 280,000 emigrated during the same period. There were 56,000 more departures than arrivals; and the

British field of human plants was therefore thinned out, rather than thickened, in this interval. Still the abstract fact remains, that the real reproducing power of man in a state of civilisation is expressed by a fivefold increase in half century periods; at the lowest estimate, when every circumstance is most favourable to the result, twenty millions made into a hundred millions, living and dead, may be taken to be a rude expression of the powers of human fertility.

The numbers in any population, where the births represent all arrivals, and the deaths all departures, must always be in a certain ascertainable ratio to the mean duration of individual life, taken in connection with the amount of the additions by birth in each year. The number of yearly births multiplied by the mean length of individual life in years, under such circumstances, always gives the sum of the population. Thus, in 1851, when England and Wales contained eighteen millions of people, the births amounted to about 600,000; and accordingly the average duration of individual life would have been thirty years, if there had been no other drain upon the numbers than that produced by death (600,000 × 30 = 18 millions). In reality, however, as the eighteen millions represented a result lowered by the drain of emigration, as well as by that of death, the true value of individual life was considerably higher. It is only under circumstances of great exposure to deleterious influences that the expectation of life sinks so low as this in England. In the worst managed workshops in London, where men of intemperate habits sit long in a close, impure atmosphere, the average duration of life does not rise above thirty-two years; but in cities generally, it reaches thirty-eight years, and in the open country, it is as high as fifty-eight years.

Taking the eighteen millions of the people of England, then, as they stood in 1851, and assuming that one thousand a-day are to be regularly withdrawn from their ranks by the hand of death, that another thousand a-day are to separate themselves by a voluntary exodus, and that the numbers are nevertheless to be steadily preserved at the stated amount, there remains the curious fact, that some industrious and ingenious power is constantly at work, turning out daily two thousand individuals, complete and perfect in their various corporeal and mental appointments, for the replenishment and support of British society. Now this economical process of sustenance goes on week after week, and year after year, quite independently of any intentional exertion of human agency for the accomplishment of the purpose. Until recently, very little was known indeed regarding the occult operations of the creative work. Man was said to be born into the world, and a name was contrived to express the result in the abstract: it was called Reproduction. But these names explained nothing. They were merely artifices invented for the concealment of ignorance, and not devices contrived for the generalisation of knowledge. Now, however, affairs are greatly changed. The construction of the microscope has been carried to a pitch of high perfection; and, strengthened by the aid of this noble instrument, a band of distinguished physiologists have sallied forth into the widely-spread provinces of living nature, and, after careful research there, have brought back results which they have been able to apply while subsequently instituting a closer investigation into the mysteries of human organisation. The early pioneers of this adventurous band were rather given to the use of hard names, and when they were eagerly asked for information on the subject of their labours, were apt to reply that the matter was entirely involved in the virtues of *Cicatrules*, and that it was *Blastoderms* and *Cytoblasts* that accomplished all the wonders. Since then, however, other workmen have penetrated through these obscure and tangled thickets, and have made open paths that admit the light of day. One of the most interesting branches of physiological knowledge could not long remain wrapped up in the mysteries of technical phraseology, when there were such men as Mohl, Köllicker, Owen, Quekett, and Carpenter engaged in the investigation and elucidation of its facts.

The researches of modern comparative physiologists and microscopists have shown that there is a certain humble and unobtrusive little member of society who is at the bottom of the operations by which multiplication has been made to spring out of subtraction and division, and by which birth and life have been caused to push decay and death out of the path.

This worthy individual is present wherever vitality dwells. Every tree that springs from the ground is filled with countless myriads of his form, and has been so filled with it since the primeval epoch of creation. Every crimson stream that circulates through the channels of animated structures is crowded with his presence. Yet his very existence was unguessed by man two centuries ago. The fact is, he possesses so diminutive a stature, that until the microscope had been constructed, there was no chance of catching even a glimpse of his person. In a general way, as many as a million individuals of his race may be lodged side by side upon the face of a shilling. In his most attenuated state, twenty millions could be comfortably accommodated upon a farthing. This omnipresent pigmy assumes a great variety of external appearances, but in all of these possesses the same essential construction and the same general form. Hence in every aspect he is designated by a family name. He is termed *Cella*, a cell, or little chamber — a place provided, so to speak, for the reception of some precious store. This denomination is not, however, altogether a fortunate one. It was conferred, indeed, before his real nature was thoroughly understood. Hence a more appropriate synonym has been invented, which is now in general use. This synonym is *Vesicula;* a vesicle. A cell is a hollow space, which may be either inclosed by walls, or may have been excavated out of some continuous mass of substance. But a vesicle is a little bladder, having both walls and inclosed cavity of necessity belonging to itself. The cell of organised structure is, indeed, properly a vesicle in this sense.

The vesicle of organised structure consists, then, of a filmy layer of delicate membrane, rolled up into the form of a bladder, or, still more correctly, of a hollow ball, the interior cavity being everywhere closed from external space. This cavity always, however, contains some kind or other of material substance. The membrane of the vesicle seems to be devoid of holes, properly so called; for not even water will drip through it under the mere influence of weight. It nevertheless does allow fluids to permeate its substance, when impelled to do so by other influences. The matter contained within the vesicle is really introduced by transudation through the apparently poreless membrane. This seeming inconsistence of passage and no passage may be cleared up by the use of a simple illustration. If half a pint of pure water be poured into a bladder, and its neck be then carefully tied up, and the whole be hung upon a nail in the wall, no water drips from the bladder. It is retained as certainly and safely as if held in a glass bottle. But, if the bladder be now taken down from the nail, and an equal quantity of strong brine be made to take the place of the pure water, the neck being closely tied again, and if the bladder of brine be then tossed into a pailful of rain water, and left there all night, it will be found on the morrow that some portion of the water from the pail has entered the bladder, for it now contains more than the original half-pint of fluid, and has swelled out accordingly. But some of the salt water also has passed out through the bladder into the water in the pail. Portions both of brine and water have really transuded through the substance of the bladder under the new circumstances in which it is placed, although no water could run through it under the inducement of weight alone. The explanation of the curious result is simply this. When a delicate membrane of the nature of bladder is so placed that its substance divides two liquids which are of unequal densities, but which at the same time have an affinity for each other, or, in other words, a tendency to mingle together, the interposed layer of membrane facilitates, instead of preventing, the admixture. Both liquids are soaked up into its imperceptible pores, as water is soaked up by a piece of bibulous paper. Then each passes off from opposite surfaces in opposite directions. The action is first set up by the sucking power the membrane exerts over the liquid, through the instrumentality of its molecules upon the liquid molecules; but it is then carried on by an operation of a distinct power, which in some instances amounts to a very considerable force. Dutrochet, who was one of the first observers that noticed this curious process of transudation of liquids through organic membranes, ascertained that there are cases in which a single square inch of organic film can sustain a weight of no less than seventy pounds of liquid after it has been sucked through its substance. Different kinds of liquid are acted upon with different degrees of energy by the same membrane. Some are sucked through in greater abundance, and more rapidly, than others; and in a general way, when thick and thin fluids are placed at opposite sides of the film, more of the thin goes through to the thick, than the reverse. Hence at first it was considered that the matter was only a case of diffusion, and that the fact was merely that liquids which were soaked into porous partitions mingled with each other, until their composition was made alike, exactly as they would have done if there had been no partition between them. Professor Graham has, however, recently shown that there is much more in it, and that it is really a case of true chemical action. The motion of the liquid never takes place unless some of the surface molecules of the membrane are decomposed and destroyed. The current of the fluid is sustained at the expense of the constitution of the membrane, and its direction and extent are determined by the nature of all the substances, solid and liquid, that are concerned. The whole phenomenon is, indeed, a result of the various attractive affinities of the different elements producing similar changes to such as take place when complex organic matter decays, and is resolved into vapour and ash during the existence of life. This view is surrounded with a peculiar interest of its own, on account of its illustrating a now admitted fact; that, in the physical operations of nature, power is never really created, but is only exchanged for some other form of force that is an equivalent to itself. In the instance under consideration, the force by which the elements of the organic molecules are held together in their peculiar condition, is thrown into a new direction, and becomes operative in making the liquids flow in determinate ways,—and the attachment of those elements in the molecules is accordingly dissolved. The more abundant movement of the thinner liquid into the thicker one used to be designated by the learned name of "*endosmose*," and the less abundant movement of the thicker into the thinner by that of "*exosmose*." But in consequence of the researches of Professor Graham, the former only is considered to be the essential portion of the operation, and it is now spoken of as "*osmose*." This word is derived from a Greek term, which signifies "pushing," and is very appropriate, inasmuch as the chemical change effected in the composition of the membrane does really "push" the liquid on through its substance. The current of the thicker fluid to an inferior extent in the opposite direction is still distinguished as "exosmose," or an outward pushing, and the Professor is inclined to think that *it* is only a modified form of the ordinary process of diffusion.

This power possessed by permeable membrane of causing fluids of different degrees of density, and of different qualities, to pass through it, so that the several molecules of each get intermingled together, is of the very highest importance in the operations of organic life. Whenever cells or vesicles, composed of delicate filmy walls, contain in their interiors a liquid that is capable of being sucked into their pores, and are immersed in, or surrounded by, some other kind of liquid of a different density or quality, an intermingling of the substance of the two fluids is sure to take place. But if the two are of such a nature that, when mingled, each has a tendency to affect and modify the composition of the other, as it is brought into contact with it, changes of a very singular kind may be effected. It is possible, indeed, that the chemical properties of the two agents may be so related to each other, that the substance contained within the cell may be converted into membrane, in every way resembling the film through which the process of transudation has been carried on, and that, of this newly formed membrane, a fresh vesicle may be moulded, within the cavity of the old one, analogous to it in every respect excepting in the condition of size. Now the simplest form of organic life that is known is merely a minute membranous vesicle of this nature, capable of producing other vesicles within itself, by imbibing through its filmy walls matters that are suited to form similar filmy substance, when united with the contents already present within.

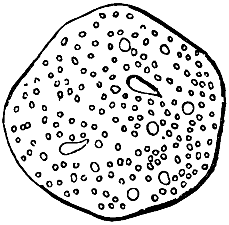
There are, upon the earth's surface, multitudes of living creatures that are nothing more than simple vesicles, thus possessing the power of reproducing their own forms. These creatures are called unicellular organisms, and they are of very high interest to physiologists for this reason: each one is so small and so transparent that (with the aid of the microscope) it can be brought under the glance of the eye at once, and, as it is a complete individual in itself, all the operations of vitality that are really essential to living existence can be watched while in progress in it. Through these unicellular organisms, men get a clear notion of the fundamental actions upon which even the complex organisations of their own bodies are based. Each of these little vesicles is as distinct and independent an individuality as an elephant or a man, and fulfils all the several offices of organic life with equal completeness. Each is seen to spring from a germ, to attract food to its own substance, to grow by the addition, and to form other vesicles out of portions of the same. Each is born, matures itself, produces a progeny, and then declines and dies, with the same unswerving regularity that is marked in the history of higher and more complex living forms.

The unicellular organisms already known are of immense variety. They are found in almost every position, into which microscopic observation can be carried. Water, both saline and fresh, is full of them. Every surface that has been exposed for a short time to the influence of moisture is covered with them. Their favourite places of resort, and therefore the situations in which they are most assiduously sought by the microscopists, are the surfaces and bottoms of still pools. They float as a scum upon the one, and rest on the mud of the other. They have also their cemeteries and catacombs. Entire strata of what have hitherto been deemed mineral substances, are now ascertained to be composed of piles of their indestructible skeletons. The city of Richmond, in Virginia, is said to be built upon a bed of them lying eighteen feet thick. Carefully as these curious little organisms are now observed, they nevertheless serve, in one respect, as a choice battle-ground for the pugnacious spirits of science. It has proved to be a very difficult task, in many instances, to determine whether they really are members of the animal or vegetable departments of nature. The Germans have fought over them with genuine Teutonic pertinacity, and indeed still wage a fierce war on their account. Ehrenberg says that, whether animals or not, they are, at least, all *animalcules;* Nägeli and Siebold, on the other hand, claim them as plants. Serried ranks of supporters rise thick on either hand to back the rival champions. Here, an observer, on one side, brings a triumphant instance, where he has seen the vesicles to swarm from one spot to another, as fishes shoal through the sea. Then, on the other side, some one shows that when they swarm, they stick fast if their heads are unluckily struck against walls and move no more; that, in fact, they have no power of avoiding obstacles that are placed in their path as the most unquestionable forms of animalcules have. Next, it is advanced, that they must be animals, because their tissues contain nitrogen. Then it is proved the vesicles of vegetable leaves do the same. Ehrenberg fed a colony of them with indigo, and stated that he saw them draw particles of the food towards a double mouth, by means of moveable processes. Siebold asserts that, in such experiments, the indigo only moves where it is in contact with thin permeable parts of the membrane of the vesicles, and that the motion then results entirely from the osmometric absorption of the water in which the particles are contained. In this lengthened controversy victory seems to be gradually declaring itself against the party of Ehrenberg. The Rev. W. Smith, who has studied the group of creatures concerned very carefully, and who has figured some hundred individuals in the first volume of his "Synopsis of the British Diatomaceæ," recently published, appears to entertain no doubt whatever on the subject. He grounds his conclusion that they are plants upon the fact that occasionally certain peculiar changes are observed to occur during the multiplication of these cells, that are of nearly an identical nature with processes long known to take place among sea-weeds, and other algæ of an unquestionable vegetable nature.

Form alone seems to be quite an insufficient guide in any attempt to distinguish animal from vegetable life, when these lowly and simple organisms are concerned; and, indeed, the distinction would be a matter of trifling importance, were it not for the fact, that there is a grand fundamental difference in the nature of animal and vegetable life, which is marked as much in these rudimentary creatures as it is in the higher developments of the two kingdoms. Plants invariably feed on the inorganic elements. Animals as constantly consume only food that has been already placed in the condition of organic structure. Trees are nourished by the air, the water, and the soil; but oxen feed on turnips and grass, and carnivorous animals upon flesh. So also the unicellular plants are sustained by air, water, and earthy matters, while the unicellular animals are nourished by vegetable and animal substances that either are, or have been, in a living state. This, then, seems to be the only characteristic distinction that can be depended upon. Plants have been designed for constructive purposes. They build up the crude elements into complex products. Animals, on the other hand, are intended for destructive offices. They waste the complex products vegetables form, and extract out of the waste various kinds of power. Whenever it can be ascertained that a simple living vesicle decomposes gaseous carbonic acid, retaining its solid constituent carbon as an ingredient of the membranes and other things it forms in its own interior, there is no longer room to question its vegetable nature. And when, on the other hand, it absorbs oxygen, unites this with a part of the carbon of its substance, and throws the result off as carbonic acid, it is equally clear that the vesicle is of an animal nature.

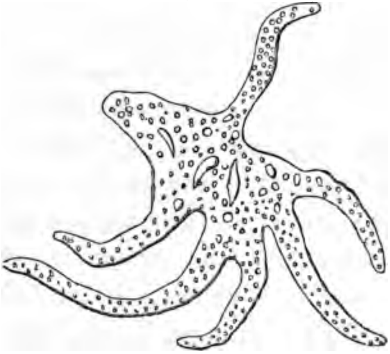
Next in importance to this functional distinction is, perhaps, the difference of the character of the membrane in vegetable and animal vesicles. Vegetable membrane is more or less rigid and stiff. Animal membrane is mobile and limp. This latter fact is very beautifully illustrated by means of a creature familiarly known as the Proteus, but more scientifically distinguished as the Amœba (a Greek word that implies "the changeable"), which Dr. Carpenter has described with considerable care. This Proteus inhabits stagnant and impure water, where decaying organic matter abounds; and it is undoubtedly a simple membranous cell possessing independent animal life. It is merely a bag of soft membrane closed everywhere, and wearing an irregular spherical form like that of the accompanying figure (*fig.* 1.) when at rest. It is able, however, to move about in search of its food, and it performs its movements after a most extraordinary fashion. A current all at once arises in the fluid contents of the vesicle, and, in the direction of this current, the membranous wall is pushed

Fig. 1.



out, as if before its impulse, until the projecting part looks something like the finger of a glove. Other similar tubes are then thrust out in different directions, until the creature presents some such grotesque and indescribable appearance as that which is sketched in the figure (*fig.* 2.), which is a greatly magnified

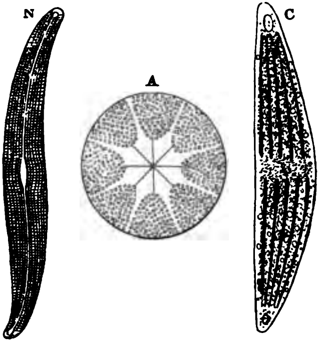
Fig. 2.



portrait. If, during this change of form, a morsel of nutritious substance of any kind chances to come in contact with some portion of the membrane, this rolls itself over the morsel, until it has entirely enclosed it in an ample fold, and so formed for it a sort of extemporaneous stomach. Here the food lies in contact with the membrane until it is dissolved, and taken into the interior of the vesicle by osmometric absorption. The digestive sac then unfolds itself, and the vesicle proceeds to seek for other food in a similar way. The creature, however, does not seem to possess any consciousness. It appears to be merely rolled over this way and that before the sets of internal currents, upon the chance that some appropriate fragment of decaying substance will soon be lighted on. Possibly the propinquity of suitable food may in a degree determine the direction of the internal streams. Very curious, indeed, is the spectacle of this singular creature, clumsily rolled along by currents acting upon its own limp skin from within. The uncouth Amœba, nevertheless, must be received as the rudimentary type of the animal side of organic being.

The more abundant rigid cells, estimated by the same standard, certainly take rank with vegetable forms. They are microscopically minute vesicles of every conceivable variety of simple shape: now they are prisms,—now triangles,—now quadrangles,—now lines and crescents,—and now discs and figured shields, or boat-like objects, either drawn out into pointed prows, or gracefully bent into S-like curves. They are all of them made, however, out of essentially the same elements, a thin film of rigid membrane, rendered more resisting and firm by the presence of a couple of little shields or shells of flint on the outer surface. At each extremity in the lengthened vesicles, or round a circumferential line in the circular ones, the inner membrane is left free from the flinty deposit, in order that the water in which the creature floats may there have a ready passage to and from its interior cavity. The flinty shells in many species are beautifully marked with symmetrical lines and dots that are formed by a peculiar arrangement of the siliceous substance. It is these little flinty coats that constitute the enduring portions of the creatures; and from this brittle armour they have received the appropriate designation of "brittleworts." The rigid mail-clad vesicles, when alive, move in straight lines by a series of rapid jerks that carry them forward for a little time, and then bring them back upon the same course. The most lively travel in this way through as much as an inch in three minutes; the more sluggish ones are an hour getting over the same journey. These odd jerking movements do not seem to be caused by any exertion of the creature's will, but by the mechanical impulse of fluid currents set up by osmose. The little bodies are so light that they are themselves drifted along by the stream, whenever any very strong suction is exerted from the uncovered and permeable portions of their membranes. These uncovered and permeable portions being restricted to certain parts of the wall of the vesicles favours the production of a sensible impact in some one given direction. Such could not happen if the vesicles absorbed equally from all directions by their entire films. In all probability these brittleworts are the rudimentary types of the vegetable side of organic existence. They seem to be, in their rigidity and fixedness, the exact contrasts or opposites of the limp and versatile Amœba. In common fairness, therefore, some of their family portraits, too, must be presented to the reader. N (in *fig.* 3.) represents the appearance of one of the commonest and most interesting kinds, known as the "Navicula," or "little boat." A is the picture of a species belonging to the old world. It is the shield of a creature dug out of its catacomb, where it had lain some thousands of years before it was disturbed from its rest by the ruthless hand of modern science. Each little ridge and streak of flint is as distinct and clear as when it was first deposited on the delicate cell film that served as its mould. Philosophy, in its en-

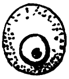
Fig. 3.



deavour to make amends for its act of sacrilege, has bestowed upon this beautiful shield a brilliant name. It is called the "Asterolampra," or "star-shiner." C is the picture, not of a true brittlewort, but of a first cousin of the family, which has a horny, in the place of a flinty coat, and which bears the homely designation of "Closterium," or "the spindle." These portraits are all magnified representations to the extent of some sixty thousand times.

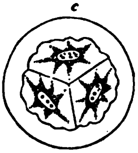
The brittleworts, although spoken of in general terms as unicellular organisms, are rarely found in complete isolation: they are mostly associated together in pairs. The longitudinal line in N of *fig.* 3. marks the division of this object into equal halves. It is each of these halves that is in reality the distinct vesicle, and that is in itself the unicellular organism. But this does not very materially affect the accuracy and fitness of the general denomination, for it has been ascertained that their habit of presenting themselves in couples is merely a result of the peculiar mode in which they are formed, which will be more particularly alluded to presently. There are, however, cases of isolated vesicles of rigid vegetable membrane, which are quite distinct in their own individual vitality, and which therefore are more strictly the counterparts of the animal Amœba. The figure (*fig.* 4.) is a sketch of the appearance of one of these when very highly magnified by the microscope, and will serve to illustrate the essential characters of what may be termed the rudimentary type of cell life. It is the earliest state of a simple plant or liverwort, known as the Anthoceros. It is readily seen to consist of a very delicate film, so transparent that it allows the substances contained within it to be perceived through it. This contained substance is a thick liquid, in which a great number of minute opaque granules float about. But it will be noticed, that amongst these granules, there is one larger body. This larger body is slowly and progressively formed: it first makes its appearance as a speck, barely larger and more conspicuous than its companions, but then soon assumes a greater importance by attracting to

Fig. 4.



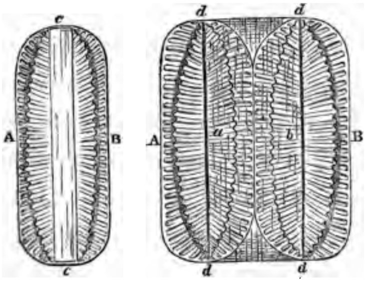
itself portions of the surrounding molecules, and attaching them to its own substance; in short, it grows until it becomes itself a hollow structure, like to that in which it is held, in all particulars saving in size. It is then a vesicle within a vesicle — a kernel to the vesicular nut, so to speak: on this account, it is called the *nucleus*, or kernel, of the containing cell. For a certain time both the larger vesicle and its nucleus increase in dimensions together with a pretty even pace; but at length this process of growth is arrested, and another sort of business is taken in hand; streams of the finer granules begin to flow backwards and forwards with great determination, between the outer wall of the vesicle and the imprisoned nucleus, and a very delicate filmy lining is soon perceived to be separating itself within from the wall of the vesicle, and to be extending a fold inwards towards the kernel in the form of a flattened ring. This delicate lining appears to be a structure of great importance and of high vitality, and, accordingly, it has been honoured by a distinct appellation: it has been christened by the German physiologist Mohl, the "primordial utricle," or, in simple language, the "original little bag." This inward fold of the "original little bag," or lining, at last constitutes itself a complete partition across the vesicle, cutting the kernel also in half as well. Fresh cell film is then produced by it within its own fold; and so what was at first one vesicle is metamorphosed into two; these then both grow in their turn, form new nuclei in their interiors, and then develope partitions, and divide; and this process is continued again and again, generation after generation of fresh vesicles being produced by it. In *fig.* 5. the condition of the cell drawn in *fig.* 4. is shown after four partitions have been developed, and four distinct cells have been called into being (one of them is on the farther side of the object, and invisible, in consequence of lying beyond the focal reach of the microscope). The brittleworts multiply by a process very similar to this: they split into two, and then each half

Fig. 5.



splits again; and this goes on for generation after generation. They receive from the learned the family name of "*Diatom*," which is only the Greek way of saying "cut into two." This habit of division by direct splitting through their lengths accounts for these vesicles being constantly found in pairs. In reality they are always seen in process of dividing; each individual is becoming two, and is therefore contemplated as a couple. In the drawing (*fig.* 6.),

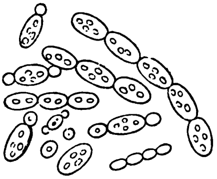
Fig. 6.



A and B are two individuals of a brittlewort, known as the Surirella, and coupled together in the ordinary way. It will be observed that they are separated from each other by a broad intermediate band, *c c*. By slow degrees this band grows wider, until it has the dimensions shown at *d d d d*. Then a new half is formed out of it for each of the primary vesicles A and B; and the creature then consists of four individuals,—two old, A and B, and two new, interpolated between them, *a* and *b*. But the union is next so far dissolved that A and *a*, holding together, fall asunder from B and *b*, which also remain attached; and thus A and B become each double, and soon after are split in their turn in the same fashion.

New vesicles are, however, often made in a somewhat different way. The delicate lining of the parent vesicle, instead of growing inwards into its cavity as a partition, is pushed outwards, carrying a sort of pouch of the external cell-wall before it; this pouch then, by degrees, gets nipped by a narrow neck of communication, and at last falls off completely as a distinct offset or bud; the parent vesicle is then not resolved into two new ones, as in the cases described above, but forms a young one, and continues its own independent existence in common with the offspring it has produced. A beautiful illustration of this mode of cell propagation is afforded by a very familiar material, the common yeast, so extensively employed in producing fermentation. Yeast consists almost entirely of a multitude of little vegetable vesicles, or unicellular plants; and so long as fermentation is going on in any fermentable liquid containing them, each of these vesicles pushes forth one or two buds, which soon become mature cells, and bud in their turn. In this way a single individual becomes five or six in a few hours, which cling together so long as the fermentation continues, but fall asunder as soon as it stops. The figure (*fig.* 7.) represents a chain of the buds of this little yeast-cell clinging together in a line. They are drawn as seen by the microscope, when magnified many thousands of times. When vesicles multiply by splitting into pieces, physiologists term the process *fissiparous;* that is, producing by fissure or division. When they multiply by the formation of external buds, they call it *gemmiparous*, that is, producing by gemmæ or

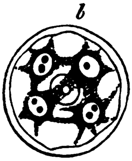
Fig. 7.



buds. Both modes of reproduction are, however, merely modifications of the same operation. In each case the result is produced by folding the delicate lining of the parent vesicle, and then by cutting a piece of it off; but in the one instance the folding is an inward extension, and in the other it is an outward bulging.

The unicellular organisms of an animal nature are multiplied in very nearly the same way as the vegetable vesicles; the main difference between the two forms of vesicular existence is simply this. The delicate filmy lining of the vesicle in the vegetable cell forms an outer investment for itself of denser membrane; and upon this investment its character for firmness and rigidity depends. In the animal cell the filmy lining, on the other hand, covers itself with no outer investment, but remains limp and delicate, and is indeed the entire cell itself. The delicate lining of the plant vesicle is indeed the true analogue of the animal vesicle. It, like the entire substance of the latter, is made of a richly azotised and highly plastic substance; whereas the outer vesicular membrane secondarily deposited in the plant vesicle, is unazotised and of a less plastic nature and less complex organisation. In the animal vesicle, the contained kernel or nucleus is always present during the period of active life, and seems indeed to play a more important part in the process of multiplication than it does in the plant. When the vesicles are about to be formed, the kernel contained within the parent may commonly be seen to separate into several parts, each part then drawing its own share of the vesicular membrane about it to constitute a fresh vesicle. Often kernels may be observed to appear all at once in organisable liquid, without having manifested any perceptible connection with the previously existing vesicular forms; and these then proceed in the common way to convert themselves into mature vesicles. In these cases, the organisable liquid has, however, always been, it must be remembered, originally prepared in the interior of living vesicles, and has been thence poured out, in consequence of the rupture of their walls; hence it is now generally considered that the spontaneously originating nuclei arise from invisible germs, that were first called into existence within the cavities of living vesicles, and that have been subsequently discharged thence, to proceed in their development in external freedom. The figure (*fig.* 8.)

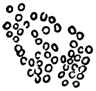
Fig. 8.



is a sketch of a vesicle with four distinct nuclei, besides the original one, forming in the cell liquid.

An immense variety of these unicellular animals is found floating about in stagnant pools. These are amongst the creatures that are commonly spoken of as animalcules. They invariably make their appearance in water that contains decaying organic matters, provided that it is exposed to the air, and the temperature is moderately warm. One species sometimes presents itself in such abundance that, it has been calculated, no less than eight thousand millions of individuals may be contained within a drop of liquid a tenth of an inch across. As may be imagined, after this statement, these animalcules are of extreme smallness. *Fig.* 9. is a group of portraits of them, magnified half a million of times. That is to say, half a million of the real creatures could be lodged on the surface occupied by each of the little circular figures. This species has very appropriately been called the "twilight Monad" (*Monas crepusculum*), "monas" being the Greek for unity. Nothing else can ever be distinguished in it, but the thin transparent film of which its walls are composed, and the nearly clear space within. It is the "Unit" that forms the dawn, so to speak, of animal existence. But it possesses great activity, and swims about with surprising energy and ease. Its movements are as completely contrasted to the sluggish jerkings of the brittleworts, its vegetable allies, as anything can be conceived to be.

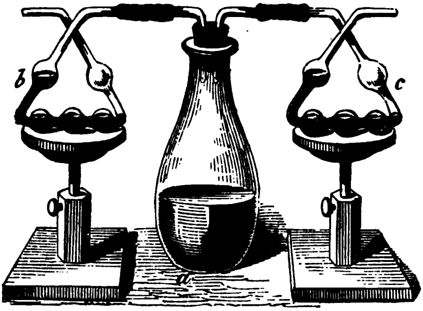
Fig. 9.



It was once imagined that these animalcule forms could be spontaneously called into existence in impure water, by the mere gathering together of their elements out of the liquid;

but it is now admitted on all hands, that they can only be produced from living and organised germs, of like nature to themselves. When they appear suddenly in water that was a short time previously free from their presence, they do so, either because the germ-vesicles, from which they spring were lying latent in the liquid, or because those germ-vesicles had been conveyed into it by the atmosphere. Professor Schultze has contrived a very ingenious method of proving this position. He employs the apparatus sketched in the figure (*fig.* 10.). He places in the glass flask represented by *a*, an infusion of organic substance in which it has been ascertained that animalcules are speedily

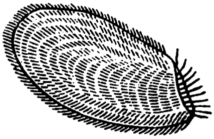
Fig. 10.



developed when it is left exposed to the air, and boils the infusion in order that the vitality of any germs that may be contained in it shall be destroyed. He then connects the neck of the flask, by means of a cork, with two bent tubes (*b* and *c*), in one of which a quantity of caustic solution of potash is placed, and in the other of strong oil of vitriol. Having completed these arrangements, he allows the apparatus to stand several days, and frequently causes air to pass through the flask by sucking it through the tubes. Such air, however, can only get into the flask by bubbling through one of the caustic liquids by which its portals are guarded on either hand; and the consequence is, that it too is deprived of every vital germ that may be floating in it, as these undergo the caustic ordeal, and that no animalcules ever appear in the infusion. But if, after some days, the cork is removed, and the flask is left open to the air, a shoal of animalcules is produced in the infusion in a very few hours.

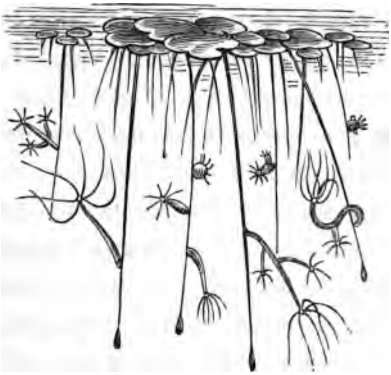
Some singular forms occur among the animalcule tribes, which are of very great interest on account of their marking the first stage of departure from the simplest condition of unicellular organisation, the vesicular type. These creatures have the appearance of being bags of membrane with open mouths, instead of closed vesicles; and the open mouth is ordinarily surrounded by a fringe of very delicate hairs, technically distinguished as cilia, which bring currents of food into the open orifice, by waving rapidly backwards and forwards. In the figure (*fig.* 11.), the appearance of one of these creatures, known as the gaping Leucophrys, is shown. In these bag-shaped animalcules, however, the departure from the simplest type of the vesicular form is really less than it seems at the first glance. The inside of the sac, or the stomach, as it is called, is merely a pouch of the external membrane. Imagine that some such limp bag as the Proteus has been described to be, having folded itself over a large morsel of food, retains permanently the doubled-up

Fig 11.



form it has been induced to take, leaving a sort of mouth open where the inward reflection of the vesicular membrane takes place; it would then represent exactly the condition of the pouch animalcules. In some of the larger species of an analogous tribe, indeed, as, for instance, in the green Hydra, which attaches itself to the rootlets of the duckweed, as represented in the figure (*fig.* 12.), the body has been turned inside out, the skin being made to take the place of stomach, and the stomach of skin; and yet no harm whatever has resulted from the change. These bag animalcules mul-

Fig. 12.



tiply by throwing off buds externally, or by subdivision, exactly in the same way with the spherical or simple vesicles.

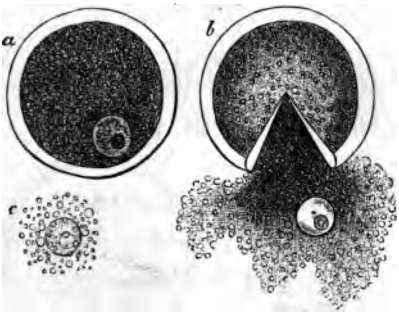
Both plants and animals, then, in their most rudimentary and simple form of living existence, agree in certain important particulars. They are both isolated vesicles of membrane, possessing the power of absorbing fluid nourishment into their cavities, of growing to a certain extent out of the material thus acquired, and of then forming a brood of living vesicles in all respects like to themselves, either by internal subdivision, or by external budding. In some instances this production of new forms out of old ones goes on with inconceivable rapidity. It is stated, on very high authority, that one case is known in which this multiplication of vesicles cannot be carried on at a less rate than that expressed by the formation of sixty-six millions of cells every minute, although all the vesicles concerned have been originally produced from a single parental one. The entire number of descendants any one parent vesicle is able to produce before its energy of multiplication is exhausted, is not at all known. There is no doubt the number must be incredibly great, although varying considerably in different cases. The period, nevertheless, at length arrives when the limit is reached. Each parent vesicle has within itself energy to produce a generation of a certain extent, but no more; and when this has been achieved the work of reproduction comes to a stand. Professor Carpenter has proposed to call the entire generation of living vesicles that are produced out of one original parent by a collective name; and, for reasons that will be presently apparent, this is a very convenient proposal. Each *entire generation* is in his nomenclature a *zöon*, (*zoon*, Greek for animal). And every separate vesicle that forms an individual in this zöon is a zöoid. Thus, suppose, for instance, that one active vesicle of the yeast plant were dropped alone into a tun of sweet wort ready for fermentation, and were there to bud and multiply until a hundred millions of similar vesicles had been produced, each of these hundred millions would be one of Dr. Carpenter's zöoids; but all the vesicles contained at any one time in the tun would be a zöon. This is a very important generalisation, on account of the facility it affords for explaining what happens when complex instead of simple structures of organisation are concerned.

Where the lowest and rudest kinds of vesicular life are alone in question, each new generation is cast off as rapidly as it is produced, and thus the entire zöon is widely scattered over the face of the earth. This, however, only happens with such rudimentary structures as the monad animalcules and many of the diatoms. In all other instances, the zöoid vesicles that are formed from one parent show more or less of a tendency to cling together. It has been stated that the vesicles of the yeast plant hang together in strings so long as the fermentation of the liquid in which they are developed continues. Many Diatoms form chains after a similar fashion, sometimes holding together by the corners of their quadrangular frustules, at other times constituting stair-cases and jointed bars of very singular outline. In the higher developments of animal life, *all* the zöoid generation produced from a parent vesicle is retained in one skin. None are allowed to be scattered abroad until their work in the individual economy is finished. Each animal is therefore in itself one zöon of

Dr. Carpenter. In the highly developed plants, the zöoids of a single generation are also attached together; but in this case subordinate clusters are capable of being removed from the general mass, and yet of possessing the power of individual life and further growth. Some plants propagate themselves by throwing off subordinate zöoid clusters of this kind; and the clusters are then called bulbs. Nearly every kind of perennial shrub and tree may be artificially multiplied after a similar fashion, by removing analogous zöoid clusters as cuttings. Cuttings are only artificially-produced bulbs. A very interesting question arises in connection with this capacity of highly developed vegetable structures to suffer division without injury to life,—the question, namely, as to whether this division can be carried on indefinitely without exhausting the reproductive power of the divided plant. Common sense and analogy at once lead to the conclusion that the process of subdivision cannot be carried on indefinitely, but that there must be a period when any given vegetable zöon would cease to produce any more productive zöoids. There are very high authorities, however, who embrace the opposite view. Mohl states very decidedly his opinion that a plant may be separated into an *unlimited number* of productive individuals by *either spontaneous or artificial division.* He says, whenever a plant extends horizontally by the growth of its circumference, as many of the acrogenous tribes like the lichens and fungi do, or when it possesses a creeping stem, and sends out roots from separate growing points, there exists no internal cause why it should ever die. Such a plant he likens to a wave rolling over the surface of a sheet of water, every moment another, yet always the same. He believes that myriads of mosses, grasses and rushes have vegetated upon peat-bogs in this way through thousands of years. And he holds that lofty trees only die, because they at length rear their growing points so high, the weight of the nourishing sap can no longer be lifted to their level from its source in the ground. Knight was of a different opinion from Mohl. He held that all the trees which have been raised by buds from one and the same stock, always decay simultaneously, and at about the same time with the parent plant. Dr. Carpenter sides with Knight, rather than with Mohl. He remarks that propagation by budding cannot be carried on to an indefinite extent; for although "grafts often last longer than the stock from which they are taken, yet the varieties thus multiplied at last lose their vigour, and die out." Some physiologists incline to account for the potato disease, unfortunately too general of late, upon this principle. They conceive that, with regard to this plant, the period has at length come when the reproductive power of the old parent vesicles, from which the tubers at present in existence have been propagated by offsets, has exhausted itself. The strong probability is, that this question resolves itself simply into one of time, and not of fact. All collateral evidence is opposed to the conclusion that any organic structure can go on multiplying offspring, and extending its own substance, for indefinite periods, without the exhaustion of the productive energy by which the result is attained. It can scarcely be doubted that, in the highly-organised plant, as in the highly-organised animal, the multiplication of parts, by the constant subdivision of zöoid vesicles, must be admitted to be performed at an expenditure of reproductive capacity, and that there is a limit to the operation, although that limit may be considerably less narrow in the case of the plant, where *only growth* is to be effected, than in the case of the animal, where a very much higher result is superadded to the growth.

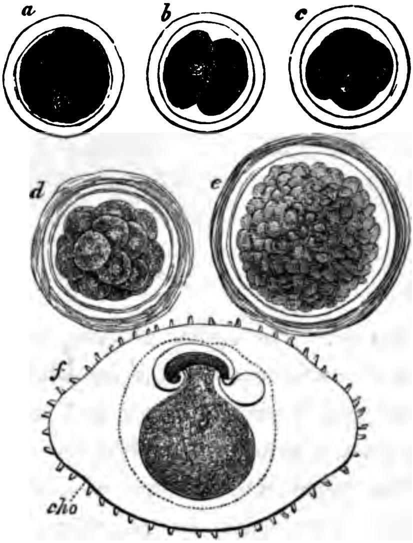
To leave this debateable ground, however, and to return to the region of ascertained fact, there is no doubt regarding what happens where the higher and more perfect forms of *animal* life are concerned. Every animal, be it what it may, the colossal elephant, the vigorous lion, the lord of creation himself, all commence their terrestrial careers as simple monads. They are all unicellular creatures before they assume their more dignified and complex conditions. Man begins life as a small membranous vesicle full of fluid. *c* (in *fig.* 13.) is a picture of his important person in the primeval stage of its existence! In *a* the primary vesicle is shown contained within the case or parent cell from which it is developed, and in which is also packed away a quantity of food provided for the early nourishment of the young creature. In *b* the protecting case is broken; and the germ-vesicle, with its environment of nutrition, have escaped from the ruptured cavity. The vesicle absorbs through its walls the nourishment that is furnished for its use, and then begins to divide and subdivide, by the process already described, into generation after generation of other vesicles. This process is illustrated in *fig.* 14., where *a* shows the primary condition of the germ-vesicle of a quadruped. In *b* the one cell has become two. In *c* the two have been converted into four. In *d* and *e* the four have become a brood too numerous to be counted. At first the multiplying brood remains in communication with the body of the parent animal, and all the material that is required for the support of the

Fig. 13.



multiplication is derived from the parental blood; but subsequently this connection is dissolved, and thenceforth the developing individual has to cater for itself. A digestive apparatus is gradually brought into play; and nourishment is prepared by it from various sorts of food, from the substance of which the new broods of vesicles then draw their material. These vesicles, thus produced by the succes-

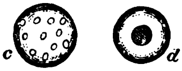
Fig. 14.



sive divisions and subdivisions of older ones that primarily originated in the parent germ, then unite together in various ways to build up the organic body of the individual. Some get encrusted with earthy matter, and are piled together to form bones; others ooze a gelatinous product through their walls, multiply therein, and then set themselves fast as cartilage; others coalesce into tubes; others arrange themselves as the contractile fibres of muscular flesh; others assume the form of nerve-threads and nerve-cells; and yet others attach themselves together to constitute films and membranes of various kinds. The immediate source from which the material is drawn that builds up all these vesicular structures, is the blood. The food, after it is dissolved in the stomach, is taken into a series of channels provided for its reception, is conveyed by those channels to the heart, and is then sent out in a circulating stream to all parts of the frame, so far changed in its character as to have acquired a red colour and a highly plastic nature. When this prepared liquid, or blood, comes into contact with the vesicles of cartilage, in the course of its circulation, it is absorbed into their cavities, and out of it fresh cartilage-vesicles are formed; so, in the same way, when it comes into communication with muscle-vesicles, or nerve-vesicles, it gives itself up to the spirit of the locality, and takes the mould of fresh muscle and nerve; and thus the various organs of the complex human body are formed through the agency of vesicular life. At *f* (*fig.* 14.) the growing mass is represented as it appears after its moulding into a definite organic shape has been commenced.

But the blood, which thus furnishes the material for vesicular growth, consists itself of an infinite number of little membranous vesicles floating in a clear liquid. The liquid is an albuminous substance not very unlike uncoagulated white of egg, but containing more water, and having also a considerable portion of salts and inorganic ingredients dissolved in it. It is indeed little else but the nutritious principles of the food, dissolved by digestion, in their crudest state. They are so crude that they require some further enriching and elaborating before they are ready to become living structure. This elaboration it is the task of the vesicular bodies that float in it so abundantly to accomplish. When transparent webs of living animal membrane are examined by powerful microscopes, two distinct kinds of vesicles are seen rushing along in the circulating streams that course through the delicate vessels. The one kind is colourless, of a globular shape, and dotted all over by little grains visible from within. The other is a flattened disc, without grains, and filled with a deep-red fluid. These two forms are represented in the figure (*fig.* 15.), as they appear

Fig. 15.

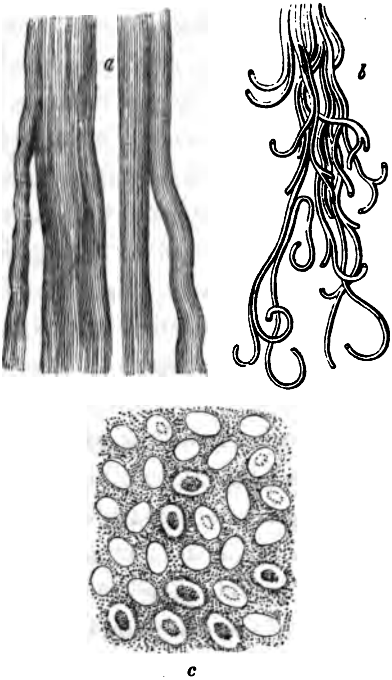


when magnified about a million and a half of times. *c* is the colourless globular and dotted corpuscle; and *d* is the flattened coloured corpuscle or disc which matures the red food of the muscles and nerves. The dark circle shown in the centre is caused by a slight depression upon the face of the disc which all these coloured corpuscles bear. The colour of the blood is entirely due to the immense number of these flattened discs that are present in it. Both these kinds of vesicles are called the "corpuscles" or "little bodies" of the blood. And they deserve their names; for they are free and distinct individuals, perfect in themselves, and each having a life of its own, and an office of its own to perform, which it perfects independently of any extraneous aid. The colourless corpuscles change a portion of the crude albuminous liquid, in which they float, into a more viscid and tenacious substance, fully perfected for the organisation of the mechanical structures of the body. They render it fibrinous and plastic, that is, sticky and prone to consolidation and formative action. The coloured corpuscles make, out of the same liquid, the rich red substance that is designed to be the nourishment and support of the highest and most important textures of the animated frame, the muscles and nerves; and they also carry stimulant oxygen from the lungs to all parts of the body in which the energies of its strong chemical affinities are required to act. All this these delicate vesicles effect, merely by absorbing the albuminous liquid osmometrically into their cavities. They change its nature as they do this, through the new chemical relations which they bring into play amidst the elements; and then either they burst, and mingle the substance they have formed with the general stream of the blood, or they carry their treasures with them, and give them up, still by an osmometric action, to the different structures requiring the contribution. Such is the character, and such are the objects, of these very curious little bodies, the blood-corpuscles. They are independent living vesicles, entrusted with the task of perfecting the composition of the stream in which they float, in order that it may be finally and fully adapted for its office, the nourishment of the organic frame.

Of the successive broods of vesicles that are formed from the original germ, some get choked up or encrusted with inorganic substance, or woven together into dense fibrous textures, and then become incapable of all further vital operation. They remain after this like bricks that have been built into walls, constituents of more or less permanent mechanical fabrics, and are unchanged through lengthened periods of time. Of this character are such enduring substances as bone, cartilage, horn, and hair. *Fig.* 16. illustrates the composition of such textures.

c is a representation of the intimate structure of cartilage; in it the original cells are seen set in a dense deposit, which they have themselves formed, and poured as a sort of liquid plaster around their walls. *a* and *b* show how cells get altered into fibres, when strong membranes have to be formed, that have no other offices to

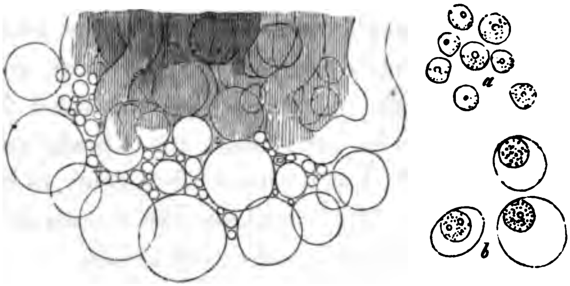
Fig. 16.



fulfil than the mechanical ones of connecting, protecting, and supporting. These fibres are all cellular nuclei in their earliest conditions; and they subsequently get lengthened out and consolidated by plastic matters, until they form strong threads convenient for inweaving together. If the membrane thus fabricated is required to be unyielding, the threads are straight, and closely compacted together, as in *a;* but if it is to be elastic, the threads are comparatively loose, and curled, as in *b.*

With the great majority of vesicles called into being, the case is, however, far otherwise; they undergo little transformation in themselves, but run rapidly through a very short existence, performing certain important offices, reproducing their kind, and then dying away from the scene. The corpuscles of the blood belong to this category; the vesicles of muscular fibre and of nerve-substance do the same, for every exertion of muscular or nervous force is of necessity attended with the destruction of vesicles. The contrast of the character of these actively vital vesicles, to those of the encrusted ones, is very well exhibited in *fig.* 17., which represents a portion of the brain of a cat greatly magnified. At *b*, three of the cells are seen separately, with nuclei inside of them;

Fig. 17.

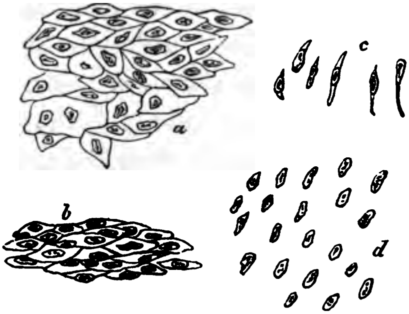


at *a* is shown a cluster of nuclei which have escaped from the parent cells. The vesicles of secreting glands gorge their cavities with the peculiar matters which they separate from the blood, and then fall off into the ducts provided for the conveyance away of these secretions, bursting and discharging their contents in the act. All the nutritious portion of the food that is consumed by the adult, day by day, is used to support this wonderful process of vesicle-multiplication; the organic life of the body, and, to a large extent, its animal powers also, are the direct result of vesicular activity; but, after a certain period of time, vesicle-production flags, the formative force handed down from the parent vesicle gets exhausted by diffusion amongst its enormous progeny, and then the life of the individual body, which has been all along dependent upon this series of operations, is of necessity arrested too. The primary germ-vesicle of animal existence can only produce a brood of a certain definite extent; and when the numbers of this brood have been filled, all further activity stops, and with it, therefore, the organic life of the individual, whose body is made up of the vesicles. Natural decay, in animal bodies, is simply the exhaustion of the vesicle-forming energies of their frames; when no more broods of vesicles can come into being to carry on the operations of the various organs, those organs cease to be active or living, and death ensues.

How is it, then, that death does not involve the races of animals, as well as their individual forms? How is it that the numbers of animals multiply, even while their own bodies are hastening towards inevitable decay? This end is attained by a special provision instituted for the renovation of the productive powers of certain of the vesicle progeny. These speciallyrenovated vesicles are then able to separate themselves from the zöon of which they were originally framed a part, and to form new zoa like to it in all essential particulars. There is thus, in the economy of the higher animals, an apparatus designed for the conversion of destruction into production, and it is upon the working of this apparatus that the result, properly termed "reproduction," depends. Reproduction, in this sense, is the communication to a single zöoid vesicle, formed within a complex zöon body, of the capacity to take upon itself the production of a new and independent zöon brood, of like complex nature. In the lower forms of organic life, each vesicle seems capable of undertaking to do this, to a very great extent, if not indefinitely, without the reception of any new influence or impulse from without. In the higher forms, the productive activity of the original vesicle is entirely spent in the development of the brood that is required to carry on the various functions of the richly-endowed and complex body which is to be constituted by their agency; and hence some separate vesicle or vesicles of the brood need to be set apart for the reception of the fresh formative influence that will be able to start them upon an independent career of their own. These reserved vesicles, designed for the continuation of the race, are not allowed to take any share in the construction of the individual body. They are placed aside in receptacles suited to their safe preservation; and in these they are kept carefully apart from the rest of the vesicular system. They seem to be, so to speak, the final efforts of vesicle life; for although still vital, they have no power to multiply until the capability is communicated to them by an agent external to themselves. If they are separated from the system without having received the formative impulse, they fall to pieces, or dissolve away, instead of producing their broods. These living vesicles, then, which have no multiplying power until they have received a vivifying influence from without, but which, after such reception, become so active that they can produce sufficient vesicle-broods for the formation of a new complex body, like to the one from which they have been cast off, are distinguished from their organ-constituting congeners by the name of "germ-vesicles" (from "*germino*," to branch out, or bud). A germ-vesicle, be it remembered, then, is a zöoid produced in the midst of a zöon, but which has no power to take a share in the general working of that zöon, and no vital value of its own until a new influence has been communicated to it, but which then immediately rises to the dignity of being a zöon itself, and accordingly separates forthwith from the parent zöon, and begins an independent life of its own. The reason why this arrangement becomes necessary in the economy of the higher animals is apparent when all the circumstances of the case are considered together. The work the animals lowest in the scale of life have to perform is so simple that each membranous vesicle is able to accomplish the task by itself, and without any aid beyond that derived from the properties of the substances by which it is surrounded; this work is generally confined to the conversion of one kind of substance into another; but the operations of the creatures standing higher in the scale of nature are of a far more complex kind. Muscular fibres have to be moved, and sensation has to be produced; instinctive actions have to be effected; and, in man, even the wondrous processes of mind and intellect to be carried on. To effect all this, nearly every vesicle that can be produced from one germ, before its formative power is exhausted, is needed; for every action, whether mechanical or mental, is of necessity dependent upon vesicular destruction; hence, then, nearly all the vesicles formed from one zöon are retained for the service of *its* system, the germ-vesicles reserved for reproductive purposes constituting the only exceptions in the case. The original formative power derived from the vivified germ is employed, among the lower creatures, merely in producing vesicles in enormous numbers, that have very low offices then to perform beyond the work of reproducing themselves. Among the higher creatures, the original formative power is *exhausted* in building up a variety of organs, that combine to effect a more elevated order of functions. Each germ-vesicle of the lowly species of animal life produces myriads of individuals capable only of accomplishing very rudimentary offices during a short period; each germ-vesicle of the highest species of all perfects during threescore years and ten a single nobly endowed and rational creature, capable of effecting wonderful efforts of ingenuity and thought; and all the activity it can spare from this object is that necessary to the production of a few dormant vesicles, capable of being subsequently roused to independent life.

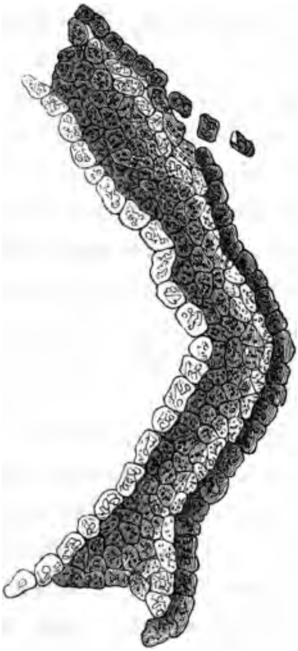
Many surprising statements have been made regarding the extraordinary progenies single germ-vesicles of the lower species scatter abroad. Calculations regarding them mount up from millions and billions to trillions and quintillions. In reality, however, the same profuse productiveness is found within the frame of each human creature. The external surface of the body is protected by imbricated layers of dry cells piled over each other, which are constantly falling off, and then as constantly being renewed; its internal passages are every where lined with layers of cells which separate mucus from the blood for the protection of the subjacent membranes from injury, and which die in the effort of secretion; the digesting cavities and other absorbing parts are covered with myriads of little living vesicles, which drink in the nutritious liquid that is admitted into the system, and then decay in yielding up their contents to yet other vesicles. The secreting glands — liver, kidneys, and the rest — are all clusters of absorbing cells, which are continually gorging themselves with the principles it is their office to separate from the blood, and then falling away like satiated leeches. Every so-called muscular fibre is a tube crammed with membranous vesicles so small that ten thousand of them can be laid side by side within the length of an inch, and which are constantly suffering destruction and renewal. The nerve masses — such as are contained in the brain and spinal cord — are composed of multitudes of vesicles, packed away amidst meshes of minute blood-vessels, so exquisitely delicate that they multiply and decay literally with the rapidity of thought. The blood, as has been before stated, is full of vesicles always dying and yet always reproduced. Every vital action within the frame is performed at the expense of vesicular life, and this destruction of vesicles often goes on for seventy or eighty years before it ceases. Yet all the vesicles so destroyed are really descendants of the one primary germ-vesicle that was originally vivified for the production of the individual! When all this is taken into consideration, it really seems that the absolute productiveness of the human germ-vesicle approaches as nearly to an unlimited and indefinite power as does that of the vegetable germ-vesicle, when plant after plant and branch after branch makes its appearance through centuries of time. The following figures, taken in connection with *fig.* 17., illustrate very well how it is that living and changing vesicles are built up into the different textures of the body. *Fig.* 18.

Fig. 18.



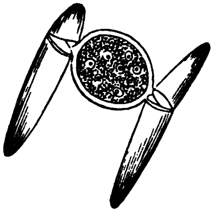
is a representation of the structure of the lining of one of the great blood-vessels of the sheep. *a* and *b* show the cells laid together in a sort of pavement, each with its nucleus or reproductive kernel visible within; *c* is a cluster of the separated vesicles, sketched sideways, to indicate their flattening; *d* are the reproductive nuclei, removed from the cavities of the vesicles. *Fig.* 19. is a drawing of the vesicles which are packed together to form one of the channels of a secreting gland in the rabbit. In this drawing the object is magnified superficially ninety thousand times.

Fig. 19.



A very remarkable proceeding has recently been observed to occur amongst the brittle-worts, which has been considered by some physiologists to bear upon the interesting subject under consideration. Two little crescents, analogous to those represented at C in *fig.* 3., that were previously lying at rest some little distance apart, have been seen slowly to sidle up towards each other, until they have ranged in close proximity. Each has then sent out a small tubular projection towards its neighbour, and the two have gradually advanced until they met. A hole has then opened through the conjoined ends, and in this way the contents of the previously distinct vesicles have been allowed to mingle. After a while the tube of conjunction has then commenced to swell, until it assumed the form of a globular cell considerably larger than the original vesicles, and in the interior of this a great number of contained vesicles soon make their appearance. This state of affairs is represented in the figure (*fig.* 20.), where the large vesicle is shown between two distinct and ruptured "spindles" of a species of Closterium, the young vesicles being contained in the interior. The large vesicle is commonly produced between the two bodies that are concerned in its formation, and sometimes there are a pair. At other times it is developed within one of the combining spindles. The small vesicles produced within the circular case are termed seeds or "spores" (from *speiro*), and they are really a brood of productive cells, for they are soon cast loose from the enveloping membrane, and then begin to live for themselves. At first they are of a spherical form, and for about a quarter of an hour after they are set free from their prison, they move about in the water very actively. But they then attach themselves to some solid support, and cease to move any longer, their opposite extremities lengthen out, and their sides curve in, and so they become complete crescents or spindles, like

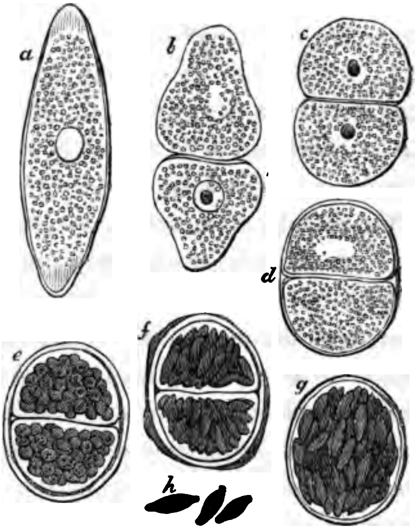
Fig. 20.



the Closteria from which the spore case was evolved.

A parallel illustration to this is afforded in the animal kingdom by a parasitic creature technically distinguished as the Gregarina. In the figure (*fig.* 21.) *a* is a representation of

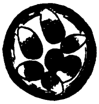
Fig. 21.



the adult form of the Gregarina. It then consists of a single cell of membrane, inclosing a large nucleus or kernel, and a quantity of granular substance. It is of a long elliptical shape, and moves about by the contractions and relaxations of its film, something after the manner of a leech. At certain times two of these elliptical cells may be observed to change their forms until they become hemispherical, and then to approach each other until they get into close contact, as seen at *b*. After this they become slowly incorporated into one body, passing through the condition represented at *c*, into that drawn at *d*. After this a progeny of minute bodies, shaped something like the brittleworts and the objects drawn at *h*, are developed in each. These are seen in progressive stages of formation at *e*, *f*, and *g*. They are ultimately cast loose from the producing cell, like the spores of the Closteria, and then grow into elliptical nucleated Gregarinæ, possessed of all the attributes of the form, *a*, in their turns.

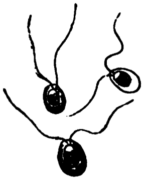
There is a little water plant known under the learned name of the Protococcus pluvialis ("primeval grain of the rain") which consists of nothing more than a thin filmy wall rolled round into a globular form, and containing in its cavity a thick liquid dotted over with granules. If one of these plants is examined carefully by the microscope, while floating in water, the granules will be seen to group themselves together under the eye, until very soon a number of cell-like bodies have been formed in the interior of the primary vesicle. Here is a picture of a Protococcus cell, in which this has happened (*fig.* 22.) Commonly these new bodies mature into globular vesicles like their parent, burst its walls, and escape into the water to begin developing a like progeny in their interiors, in turn. When this takes place, the occurrence is simply an illustration of one of the modes of cell multiplication already described. But sometimes a very curious change is made in these ordinary proceedings. The contained cells become oval or pear-shaped (as sketched in the preceding figure), instead of being globular, and a pair of delicate cilia, or hairs, are developed at one end. They then wear the appearance represented in the following figure (*fig.* 23.) So soon as these cilia are

Fig. 22.



perfected they begin to wave backwards and forwards with incessant motion, and create a

Fig. 23.



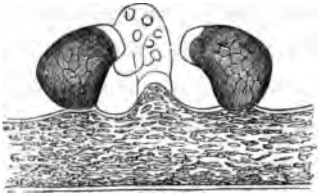
great turmoil in the little chamber where all was so calm before. At length the parent vesicle, unable to stand this internal bustle any longer, gives way before it, and bursts, and its restless progeny swarm away into the open water, vigorously rowed by the vibrations of their ciliary oars. When these ciliated cells are observed soon after swarming they look very much like infusorial animalcules. Soon, however, a change comes over the spirit of the animated dream. The elongated vesicle plumps up into a globular outline, its oars drop off, and it is a motionless sphere; a simple unicellular plant in every particular like to its parent. Its day of roving is past, and its period for settling come. The vibratile oars are merely a temporary expedient provided for enabling the "primeval grain" to flit to some distant locality, in order that it may deposit there its vital germs. This curious proceeding is a plan expressly provided for diffusing the race of this vegetable monad through the waters. Science, ever so free with names, has found a very appropriate appellation for these ciliated vesicles. They look like little animals, while performing their rapid evolutions in the water, and they obviously answer the purpose of seeds, which, wafted by the wind, transport the parent species to remote situations. They are hence termed "Animal Seeds," or, in the Greek form, "Zoospores"—(from *zoon*, an animal, and *speiro*, to sow). Sometimes the first progeny of Zoospores produces a brood like to themselves, instead of losing their oars and settling down. Then it is this second Zoospore generation that matures into the globular condition, and becomes the staid and stationary creature. Now this throws considerable light upon the nature of the movements of the spores of the Closteria when they are first cast loose from the spore case. They are in all probability Zoospores as well as spores;—aquatic seeds furnished with self-acting oars, instead of wings, so that they may be rowed off to plant the species in other spots.

Physiologists have termed the operation by which spore-cases and locomotive spores are produced through the combined influence of two distinct vesicles, *Conjugation*, or a "joining together." Mohl and other observers believe that this conjugation, occurring in simple cellular plants, like the brittleworts, is merely a modification of the ordinary process of cell multiplication, brought about to meet a special need. Thus in regard to the case instanced above, it is well known that the vitality of the little organisms concerned is destroyed whenever the shallow pools in which they find a habitation dry up. Nothing can subsequently recal them to life. But it is not so with the spore-cases and spores that are produced from them by conjugation. These retain their vitality even after subjection to long drought, and become immediately active again, and go to work at once to reproduce their kind, so soon as water is once more furnished to them. In this respect again, then, these singular little spores seem to be of the nature of seeds, being capable, like those productions of the higher plants, of remaining dormant and uninjured during the prevalence of circumstances that are unsuited to the performance of their vital offices, but at the same time being always ready to resume their productive operations directly a more favourable state of affairs is restored. Other physiologists, on the other hand, conceive that conjugation is really not an ordinary proceeding of cell multiplication, but a special act designed for the revival of exhausted vitality. They think, indeed, that it is the means by which the end is gained that just now engages attention and interest; namely, the revival of the exhausted life of the cell. They hold, that as the vesicular multiplication cannot go on indefinitely without the renewal of the productive power, this mingling of the contents of the two distinct vesicles is the measure adopted to effect such renewal, and so to prevent the speedy extermination of the race.

Whatever may be the fact in regard to this curious conjugation of the brittleworts, there can be no doubt that this mingling of the contents of two different kinds of vesicles is the means by which the process of revivification is accomplished. The two constituent cells concerned in the operation of conjugation are precisely like each other — one cannot be distinguished from the other by any external character. But in plants of a somewhat higher order, a similar proceeding is seen to take place, in which the agents concerned in the operation are of an obviously different character. There is, for instance, a common water plant, known as the Conferva of the fountain (Conferva fontinalis), which consists of a chain of united vesicles; under certain circumstances one of the jointed filaments thus formed rises to the surface of the water, so that it is partially exposed to the air. Upon the exposed parts of this filament bodies are then developed of a remarkable kind. They look at first like simple branches pushing out in pairs. But when closely examined, it is observed that each individual of the pair is of a different character from its neighbour, as shown in the accompanying magnified drawing (*fig.* 24.): one is a lengthened tube, coiled round in a spiral form, with a transparent wall, and containing a cluster of little colourless globules;

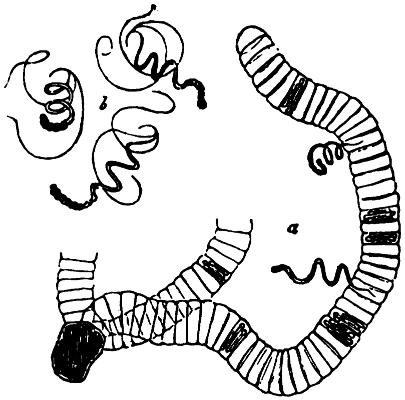
the other is an oval projection supported on a small footstalk, which swells out until it becomes a plump globe, and is then filled with deep coloured green granules. These two organs, the transparent tube and the opaque green globe, curve towards each other as they enlarge, until at last their extremities come into close contact, as represented in the figure, and remain so for some time. After this contact a young vesicle appears in the midst of the green globe, and this is slowly matured into a perfect germ, and then falls off from the filament, and begins to germinate as an independent individual on its own account. In this instance there can be no doubt that it is the contact between the two different kinds of vesicles and the consequent osmometric intermingling of their contents, that revivifies the germ included within the one.

Fig. 24.



But in the case of the common water plant of the ditches, distinguished as the Chara, the difference between the vivifying vesicle and the germ-vesicle is even more remarkable. The plant consists of a jointed tubular stem. At the union of some of these joints, there is placed an oval germ-cell inclosed within a double coat, the outer layer of which is itself composed of fine spirally-twisted tubes. Directly below this oval body projects a small orange-coloured case containing nine cavities. From these cavities there issue a quantity of wavy tubes, divided across, by a great number of partitions, into separate portions, as shown in the figure (*fig.* 25.). In every one of these spaces there lies an odd little fibre coiled up. These fibres, however, at a certain appropriate period uncoil themselves, and burst their way out of their prison, and then immediately begin to make the most extraordinary gyrations in the water, twirling round with great rapidity, and at the same time swimming forward. At *a*, two of these spiral fibres are seen just escaping from their cavities. At *b*, three of them are shown fully formed, and magnified about 160,000 times. These fibres are enlarged into hollow vesicles at their broader end; and near the opposite extremity a pair of

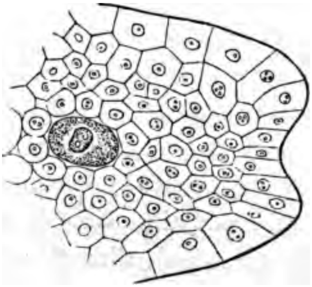
Fig. 25.



little cilia or hairs is attached. It is the restless wavings of these cilia that confer upon the fibres their peculiar locomotive powers. By means of this apparatus, these little fertilising agents are rowed to the germ-vesicles, that require their influence in order that the dormant forces of life may be awakened. It will be observed that there is a considerable degree of resemblance between these locomotive fertilisers of the Chara, and the ciliated broods of the Protococcus described some little time ago.

In the more highly developed and more perfect plants, a similar intermingling of the contents of two different kinds of cells takes place whenever a latent germ-vesicle is to be stimulated to enter upon independent life. But in these cases, the simple plan of furnishing for the occasion vibratile oars to one of the vesicles that are to be brought together, would not answer as the mechanism of the affair, because these plants are mainly adapted to live in sunlight and air, where oars are of no use, and not in the water. A very beautiful organ is accordingly contrived, which altogether supersedes the cilia. This beautiful organ is the flower. After the production of new leaves has gone on in some given plant for a considerable time, by further and further sub-division of broods of vesicles, at length a few distinct vesicles are formed which have no longer any dividing or multiplying power. Each of these dormant vesicles is then enclosed in a little membranous bag, termed by botanists the egg-bag or *ovisac;* and the ovisac is surrounded by a double great-coat, through which, however, a small opening is left at the end. The germ-vesicle, thus protected by its ovisac and double outer covering, constitutes what is known as the *ovule*, and is attached by a short stalk to the edge of a sort of leaf, which is then rolled up carefully over it, and cemented along the margin, the point being lengthened upwards into a kind of column with an enlarged head. One or more ovule-cases of this kind form the central part of most flowers, around which all the other portions are distributed in circles. In the pine tribe, in which the flowers are of a rudimentary kind, the germ-vesicle is embedded in a mass of connected cells, which form a kind of kernel, instead of being enveloped within distinct coats of membrane. In the figure (*fig.* 26.), a drawing is presented of the ovule of a pine, embedded within its cellular investment or kernel.

Fig. 26.

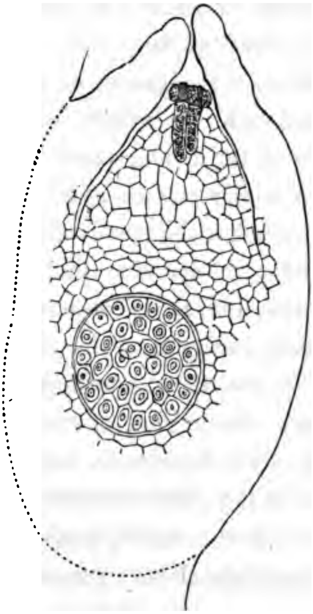


When a flower-bud first opens out, a series of delicate threads is seen clustering round the central ovule-cases. These threads are designated *stamens* (the Latin for "thread"), and carry hollow cases upon their tips; and they are enclosed within a series of coloured and green plates, the little crown and cup of the flower (corolla and calyx). A flower thus consists of one or more dormant germ-vesicles, surrounded by a cluster of subordinate appendages. These appendages are really the pieces of apparatus that are designed to fertilise the germ-vesicles, and to communicate to them powers of renewed multiplication and of independent life. The mechanical contrivances by which they are enabled to effect this purpose are now fully understood, and indeed present, when in active operation, one of the most interesting spectacles of nature at work in her subtile proceedings that the eye of science has hitherto been permitted to behold.

When the germ-vesicle, contained within the ovule of a flower, is fully prepared to be vivified or fertilised, and the flower itself is fully expanded, the hollow cases on the tips of the stamens burst, and scatter from their interiors a quantity of fine grains, looking to the eye like so much powdery dust (and hence called "farina" or "pollen," Latin for dust). Each of these minute grains is, however, a membranous vesicle filled with a thick fluid that has opaque granules floating about in it. The grain, too, has a double coat; the inner one of extreme delicacy, and the outer one dense and more or less freely drilled with pores. By the time that these grains are discharged from the stamen-cases, the enlarged top of the column that surmounts the ovule has become moist, from the presence of a tenacious and viscid liquid. Many of the little grains, therefore, when they are scattered from the stamens, chancing to fall upon the top of the column, remain sticking there, closely glued to it by the liquid on which they rest. Here, however, a change is rapidly wrought in their condition. Each grain, under the fostering influence of the viscid substance in which it is imbedded, pushes forth its internal delicate coat, through one of the pores of the outer dense investment, in the form of a sort of tube. This tube insinuates itself between the loose moist vesicles of the head of the column, and then grows downward into its substance, as the rootlet of a plant grows downwards into the soil, feeding upon the juices it finds there as it goes.

In the figure (*fig.* 27.), two of the fertilising grains from the stamen are seen fixed upon the top of the cellular kernel of the sea-pine, with their tubes growing down into the loose sub-

Fig. 27.



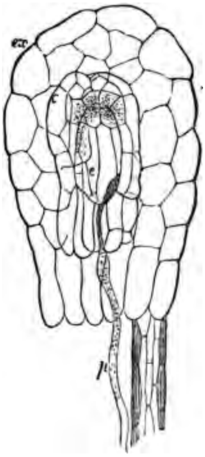
stance of the kernel, towards the germ-vesicle, which in this case is contained in the midst of the spherical mass of denser cells represented beneath.

In the most perfect flowers, the tube of the fertilising grain, when it has once commenced its progress into the loose substance upon which it has been fixed, makes its way steadily onwards, step by step, through the central portion of the column, through the cavity of the ovule-case beneath, through the minute opening in the outer coats of the ovule, which it manages to discover for itself; and so, at length, the point of the tube reaches the membrane of the ovisac that immediately contains the germ-vesicle. There it stops, and, as its contents are different in nature and density from the contents of the germ-vesicle, osmometric transudation immediately begins. Something passes from the tube through its own membrane, and through the membranes of the ovisac and germ-vesicle, into the interior of the latter, and there mingles with the materials already present in this situation.

The figure (*fig.* 28.) illustrates the way in which this happens in the case of the Meadow

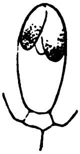
Orchis, in whose flowers the ovule is inverted, so that the openings through its outer coats are

Fig. 28.



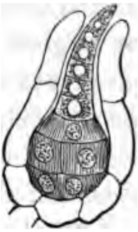
directed downwards, and so that the fertilising tube has to grow upwards. *ex* is the outer coat of the ovule made up of adherent cells. *c* is the inner coat; and *e* is the egg-bag or ovisac which contains the dormant germ-vesicle; *p* is the fertilising tube which has grown upwards, until its end is in close contact with the surface of the ovisac. It is the mingling of the two different substances contained within the tube on the one hand, and within the germ-vesicle on the other, after this contact, that essentially constitutes the fertilisation of the germ. After it has been effected, the tube very soon withers entirely away. But the germ-vesicle then begins to multiply very vigorously, adding brood after brood to its progeny, and waxing larger and larger in consequence, until at last it constitutes a fully-developed seed, prepared to be cast off from all further connection with the parental structure, and to make its own way for the future, with no other aid than such as the general elements surrounding it bestow. *Fig.* 29. is a representation of the ovisac of the Meadow Orchis in its earliest condition. There are three germ-vesicles clustered together at its summit. *Fig.* 30. is one of these germ-vesicles subsequently to fertilisation, showing a connected cluster of the newly-formed cells.

Fig. 29.



Vesicles that have the power of thus vivifying dormant germs by communicating to them

Fig. 30.



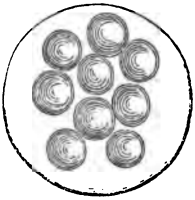
their own contents may be called, for distinction's sake, "fertilising vesicles." In all the higher classes of vegetable organisation, this mingling of the contents of two unlike vesicles invariably takes place before a perfect fertile seed can be formed. In cultivated double flowers, the stamens are all converted, by the influence of rich culture, into corollæ, and no fertilising vesicles are provided. Consequently, in double flowers, no vivification can take place, and thus the seeds are never perfected. The power of growth the fertilising vesicle manifests, while its tube is on its journey towards the germ-vesicle, is one of the most extraordinary features of the curious operation. It does not multiply into other vesicles, and so extend its substance, as happens in ordinary growth; but it simply stretches out into a longer and longer tube, until it has at last acquired from a hundred to *two thousand times* the extent of its original breadth, as the case may be. The granules contained within the fertilising vesicle, (visible in the tubes of *fig.* 27.) consist principally of starch, oil, and nitrogenised compounds of a peculiar kind. So soon as the vesicle is fixed upon the viscid top of the column of the ovule-case, these granules may be seen to begin to move restlessly up and down, from one extremity of the lengthening tube to the other. This movement is possibly merely incidental to the absorption of matters from the surrounding loose tissues for the support of the tube-growth. The period occupied by the passage of the tube, from the top of the column until it comes into contact with the ovisac, varies in different cases, from a few hours to several days; often the outer extremity of the tube and the top of the column are withered before the advancing point has reached its destination. As the tube elongates, its contents get more and more dilute, in consequence of the addition of the absorbed fluid, but, at the same time, they also become more opaque. When the tube has entered the interior of the ovule-case, if there are many ovules contained within it,—as in the substance of the Meadow Orchis alluded to before, it creeps along among them, selects one from the rest for vivification, and attaches itself to it. Very often several tubes may be seen, each trying to appropriate to itself the same germ-vesicle. Indeed the supply of the fertilising agents seems to be generally very profuse, considering the work that has to be done. Kölreuter observed that nearly five thousand fertilising grains are produced in a single flower of the Hibiscus trionum, although there are not more than thirty ovules in it to be fertilised. It has been estimated that the stamen-mass of a single flower of the Meadow Orchis furnishes no less than one hundred and twenty thousand pollen grains.

There is thus, then, in the more perfect plants, a particular provision for the renewal of vesicular reproductive force that has become exhausted. It is effected by the formation of special fertilising vesicles and by the bringing of these into connection with the latent germ-vesicles. All the splendid flowers that nature hangs out over her vegetable structures are merely variations in the means by which this important end is attained. Generally the fertilising and germ-vesicles are contained within the same flower. In some cases they are placed in different flowers produced on the same plant, or, even, the germ-vesicles are formed on one tree and the fertilising vesicles on another. Different trees of the oak, for instance, contain the catkins of the stamens and the bunches of acorns. Under such circumstances, the fertilising vesicles are conveyed to the germ-vesicles, either by the instrumentality of insects that flit from flower to flower, or floating upon the currents of the wind. It must be remarked, however, that the maturation of seeds by the higher kinds of plants has an obvious purpose beyond the mere renovation of vesicular life. It serves to effect the wide diffusion of the race over the terrestrial surface, and to preserve its existence during seasons that are unfavourable to the continuance of individual being. Thus annual plants are killed by the cold of winter. Here the production of seeds is manifestly designed as much to extend the existence of the species beyond the duration of the inclement season as it is to compensate for exhausted vesicular activity. The seed can remain dormant during the winter's cold without being killed, although the plant cannot. So, again, the oak and the fir-tree produce myriads of seeds which are scattered far and wide after falling from the branches, and which thus carry the progeny of those trees into remote positions. The seed of the cocoa-nut palm commonly drops into the waves of the Pacific, and is floated for hundreds or thousands of miles away, but at length gets attached to the margin of some low coral-reef, and there springs into a towering tree. In all these cases the vegetating powers of the parent plants continue unexhausted many years after they have disseminated their offspring, producing yet other harvests of fresh seeds. So far as the mere question of the preservation of a race is concerned, the process of reproduction by renewed fertilisation does not seem ever to be of immediate importance among the tribes of perennial plants. It appears to have more to do with the diffusion than with the preservation of species.

With the higher animals, however, the matter is altogether different. In these creatures the body is made up of a series of unlike organs, of which each charges itself with a distinct office that is nevertheless essential to the well-being of the whole. Here, then, no extension of the race by the division of the individual can be effected. No part of the complex body could be spared from its own service. Hence the *only* means of multiplication available is the separation from the parental zöon of zöoid germ-vesicles fertilised anew to fit them for an independent career. The germ-vesicles of the animal frame are developed in a mass of condensed vesicular structure provided for their protection, and termed the *ovary*. This corresponds with the cellular kernel and protecting coats of the ovule of the plant. Large distinct vesicles are formed here and there in this mass; and in each of these a true germ-vesicle slowly makes its appearance, and gradually surrounds itself with nutritious particles of an albuminous and oily nature, attracted out of the neighbouring blood-vessels; the whole then gets covered by an external membranous investment, and becomes what is designated an *ovum*, or *egg*. The outer protecting coat of the ovum is called the "*ovisac*," or egg-bag. When the ovum is quite mature and the germ-vesicle is prepared for fertilisation, the wall of the developing vesicle dissolves entirely, or is ruptured in some part, and the ovum escapes into a channel provided to convey it away. This, then, constitutes one great distinction between the mechanical conditions of reproduction in the animal and in the plant. In the former the germ-vesicle, from the first, assumes to itself the animal attribute of locomotive capacity, and goes to meet fertilisation, instead of waiting passively until fertilisation arrives. In *fig.* 13., p. 51,, *a* is the representation of a mature ovum containing a germ-vesicle and nutritious particles. At *b* the coats of the ovum are burst, and the germ-vesicle and deposit of nutritious granules are seen fallen from the cavity.

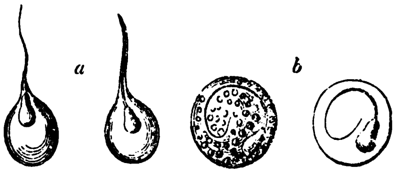
The fertilising vesicle of the animal is developed very much after the same fashion as the germ vesicle. Large cells are especially set apart for the purpose. These are embedded in the midst of a mass of connected vesicular substance and contain in their interiors granular liquid, in which several nuclei are gradually framed,—these nuclear cells then grow and mature until they become complete hollow vesicles. *Fig.* 31. is a representation of one of the large developing cells of the fertilising vesicles of the sparrow, with its brood of young vesicles in the interior. But when the interior vesicles have completed their growth, a change begins to take place in their interior cavities also. An opaque granular matter, which they contain, is moulded step by step until it has assumed a very peculiar form. A small egg-shaped body with a long coiled-up tail, is slowly shadowed forth from the cavity of the vesicle, and grows progressively more and more distinct. In *fig.* 32., this tailed body is seen at *b*, still

Fig. 31.



lying snugly in the midst of the formative granules; and in the right hand sketch with

Fig. 32.

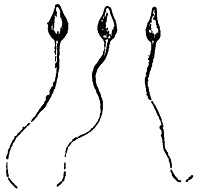


its structure perfected, the bed of granules being all consumed, and nothing being left around it but the transparent walls of its prison. At *a*, the tail projects through the transparent walls, an occurrence that may often be observed, as a sort of preparatory step to the complete emancipation of the prisoner. These figures are taken from the developing cell of a quadruped.

This odd-looking little object with the egg-shaped body, and the curly tail, is really the fertilising vesicle of the animal. It is the particular zöoid, destined to perform this office in the zöon, to whose system it belongs. It will be observed that its development is an affair of three successive generations. First the developing cell (*fig.* 31.) is made in the midst of a cellular mass. Then this cell perfects its brood of secondary vesicles (*fig.* 32.), and next each of these vesicles produces the final object of the process, the true fertilising agent. So soon as this little agent is matured, and its tail completed, the films both of the containing vesicle, and of the larger developing cell burst, and it is left in freedom. The instant it finds itself free from restraint, it begins to move about very actively, advancing by successive jerks, or swinging from side to side, or twisting round upon itself. All these movements it effects by the instrumentality of its tail, which is either waved backwards and forwards rapidly, or whirled round—the true original of the screw propeller,—or sometimes it is bent up, and then set free with a jerk, after the manner of a loosened spring. It will be at once perceived, then, that this tail is simply an oar, in every respect resembling the analogous appendage of the zöospore (represented in *fig.* 23.) It is merely an elastic hair, endowed with energetic vibratile powers, and the purpose of its vibrations is obviously in the same way, the urging of the vesicle, to which it is attached, through fluid, in this case in order that it may be transported into the close neighbourhood of the germ that is to be fertilised.

The movements of these odd little vesicles, of three of which portraits at their mature and independent age are given in the figure (*fig.* 33.), may be readily observed when they are

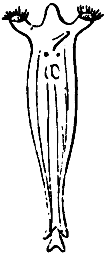
Fig. 33.



placed in a film of serum or milk, and they are exceedingly curious. Commonly the tail is lashed from side to side at regular intervals, and the head then pendulates regularly with its lashings. At other times the tail moves slowly in progressive undulations that run along its length; the body advancing gently in a serpentine course. Often several vesicles keep company together, and "go ahead" in straight parallel lines, from which they diverge neither to the right nor left. It is peculiar to some distinct kinds, in which the body is spiral, instead of being oval, to turn rapidly round upon themselves as they advance, with a sort of screwing or boring action. Upon the whole, the behaviour of these tailed vesicles is altogether so impressive and lively, that the first observers who watched them at once elevated them to a very high pinnacle in the vital scale. They conceived that they were distinctly animated creatures, complete in themselves, and with a subordinate organisation for their little bodies, and they accordingly invented for them the high sounding name of Spermatozoa. Leuwenhoek, Ehrenberg, and Valentin saw stomachs and intestines in them, and Schwann and Henle made the important discovery that they had mouths! The more precise observations carried on by the appliances and aids of a more advanced stage of physiological science, have, however, completely overthrown these fancies. It is now universally admitted, that these curious objects are merely ciliated vesicles,—that is, vesicles furnished with the appendage of a delicate hair, which is always waving in virtue of some imperfectly understood property, that is inseparable from its composition, and that therefore drags the larger body to which it is appended ruthlessly onwards, whenever it is immersed and supported in yielding fluids; and that they are vesicles possessed of a high order of organic vitality. That is, they are perfected, and perform certain vigorous offices very rapidly to their own speedy destruction. The duration of their lively existence is a very short one, when they have once been ejected from the developing vesicle.

There is another consideration, based upon an analogy, which is particularly full of interest, because it throws a little additional light upon the true character of these fertilising vesicles. In order that this consideration may be introduced in an advantageous way, it may be well, once again, to carry the reader's attention back to the real animalcule races. There is a group of these which are known under the designation of the wheel animalcules. *Fig.* 34. is an outline of the form of one of them — the slender Philodina. These creatures are characterised by having a circle of vibratile hairs set on each side of their mouths, which, when in action, look like toothed wheels revolving with great rapidity. This appearance is, however, a delusion. The hairs really only wave backwards and forwards, like the ears in a corn field bent before the wind; but they do this so quickly that the eye cannot follow the details of the operation. Now, when the body of the animalcule is free, the movements of these hairs propel it through the water; they then act as oars employed in the peculiar process of propulsion that is known technically as "sculling." But when the creature does not wish to be transported from one place to another, it fixes itself firmly by means of a forked or suctorial foot, and then, upon working its waving hairs, it moves the water, instead of being moved through it: it now waves currents of the liquid, and various little nutritious particles floating therein, into its mouth. These vibratile hairs, therefore, answer either as propellers to the body of the animal or to the surround-

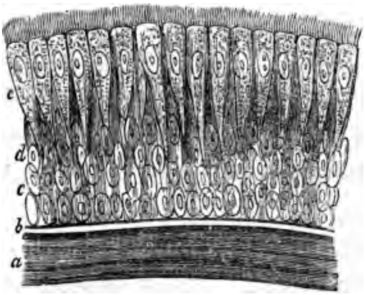
Fig. 34.



ing water, accordingly as that body is free or fixed.

Now there are certain of the vesicles employed in building up the bodies of animals that are furnished with an apparatus of vibrating hairs, precisely resembling those of the Philodina, in order that when those vesicles are fixed in their places, the hairs may constantly make currents of liquid to flow along past the surfaces they compose. Observe attentively the accompanying figure.

Fig. 35.

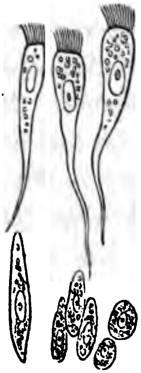


It represents the structure of the inner portion of the walls of the windpipe. *a* and *b* are a sort of basement or foundation membrane, composed of fibres like those sketched in *fig.* 16.;

c and *d* are layers of young vesicles with formative nuclei in their interiors, arranged over the membrane; and *e* is an outer layer of these vesicles arrived at maturity. These vesicles constitute the direct surface which looks into the cavity of the tube, and it will be noticed that each of them has a fringe of delicate hairs projecting from its extremity. These hairs are in constant motion, waving backwards and forwards, and by this motion they make the mucous secretion that is poured out from the vesicles advance along towards the mouth, so that it may wash the parts along which it moves, and keep them free, but nowhere accumulate so as to choke up important cavities. In *fig.* 36. some of these nucleated cells, young and old, are drawn separately from each other, the old with their fringe of vibratory hairs projecting above.

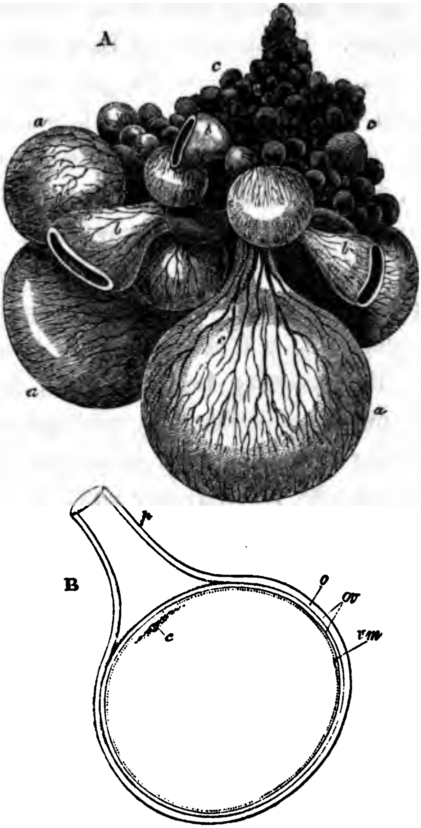
But suppose that, by some means or other, a few of these matured and ciliated vesicles were separated from each other, as in this figure, and were cast loose into liquid, the hairs continuing their vibrations. The vesicles would then be impelled along in the liquid, as the Philodina is, when the grasp of its foot is loosened. Ciliated vesicles have, indeed, been seen to detach themselves from the lining membranes of animal structures, and to swim actively about in liquid in this way; but this is only what the fertilising vesicles (the Spermatozoa) do. They are, then, merely modified conditions of these ordinary living vesicles of the tubular structures of the frame, connected with a peculiar contrivance which makes sure that they shall be cast off from connected dependence, and be left to swim about the particular business for which they are contrived, at certain appropriate times.

Fig. 36.



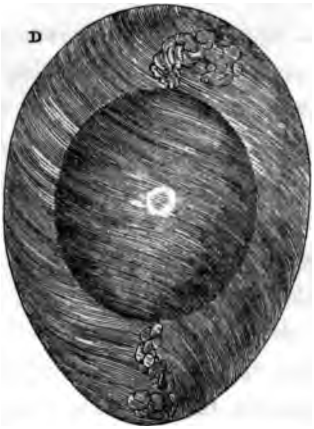
All that is necessary to effect the renewed fertilisation of the germ-vesicle of an animal is the bringing of a fertilising vesicle into contact with the membranes of the ovum in which it is contained. An intermingling of the contents of the two vesicles then takes place, osmometric transudation occurring through the intervening membranes. Most physiologists now believe, that the contents of both vesicles play their own parts in the production of the germ, that is to develope into a new creature, and that it is on this account the offspring ultimately presents some of the characters of each parent. Wāgner conceives that the germ-vesicle really bursts and mingles itself with the albuminous and oily matters that surround it in the ovum, and that the contents of the fertilising vesicle then pass into the ovum too, the entire ovum thus becoming the fertile germ-vesicle. Dr. Barry believes, that fertilisation never takes place unless the fertilising vesicles pass *bodily* through the membranes of the ovisac, and get amidst the oily and albuminous matters within. Mr. Newport, however, has been able to demonstrate, that this is by no means necessary. He has shown that the mere contact of the fertilising vesicle with the outer covering of the ovum for four or five seconds, is sufficient to ensure the fertilisation of the germ-vesicle, but that a merely instantaneous contact is not enough for the purpose. In the ovary of Birds, the maturing ova may be seen hanging out like grapes on a bunch, invested by their ovisacs, and in all stages of development. A in *fig.* 37., is a drawing of the ovary of the fowl; *a a a* are nearly mature ova contained within their bags of investing membrane; *c c* are young ova in the earlier stages of development. When an ovum is quite mature, the investing bag, or ovisac, bursts, and the ovum, consisting of a small germ-vesicle floating in a large mass of mingled albuminous and oily material (*the yolk*), and surrounded by a thin membranous coat, falls into the funnel-shaped opening of a tube that gapes beneath. At *b b b* in the figure ruptured bags are seen from which matured ova have escaped. And at B the position and relations of the several parts of a matured ovum are represented in outline; *p o* is the thickness of the ovarian bag; *o v* and *v m* are the proper investing membranes of the ovum; and *c* is the small germ-vesicle lying at one side of the large yolk mass. After the ovum has been

Fig. 37.



received into the tube with the funnel-shaped end, it passes along it with a twisting movement, getting enveloped in a quantity of viscid liquid albumen that exudes from the tube as it goes. *Fig.* 38. represents the ovum inclosed within its envelopment of albumen, which has been slightly coagulated to show the spiral way in which the mass is arranged in consequence of the twisting of the ovum. At the further extremity of the tube a sort of plaister, composed of mingled lime and membrane, is deposited over the albumen, and this

Fig 38.



sets quickly like a coating of plaister of Paris, and a perfect *egg*, in the household sense, is formed. The egg of a bird thus consists of a calcareous case, containing an oval mass of albumen. The oval mass of albumen encloses an ovum. The ovum in its turn is made up of a nutritious yolk, and of the true germ-vesicle floating within. The ovum is kept in its central place within the investing albumen, by the instrumentality of a couple of twisted ropes of albumen, one at either end. These are shown in the last figure. The large yolk, and its albuminous subordinate, of the bird's egg are designed to furnish the nourishment that is needed for the first processes of formation, while the developing creature is yet contained within the egg. They are the food of the early vesicle broods. The large dimensions of the egg of the bird, compared with the germ-vesicle, which is alone the essential part, are merely the means of adaptation to the process of hatching within the shell, which for particular reasons proves to be a convenient proceeding with the races that are so produced. In creatures of higher organisation than the bird, the nourishment for the early development is supplied directly from the parental blood, and therefore the large yolk and albumen are not required in the ova. In these species, accordingly, the ovum is of a comparatively minute size, when discharged from the ovary, and this, instead of being at once conveyed away out of the parent's body, is lodged for a season in a receptacle especially provided for its accommodation, and a free communication is there established between the vessels of the receptacle and the multiplying vesicles of the contained germ; and this connection is continued until the development of the newly forming creature is sufficiently advanced to allow of its being safely left to other provisions for support. Even then, however, it still continues for some time longer to be exclusively nourished by a secretion furnished from the parental blood before it is thrown entirely off from the dependent state. It is an unvarying rule, that the more complex and diversified the ultimate powers of the creature are to be, when its development is perfected, the more the parent does for its assistance in the earliest stages of life. Even birds are more assiduous in their care of their young, when they belong to tribes in which the animal powers attain to high degrees of vigour and excellence.

In mammiferous animals and in the human species, so soon as an ovum has been vivified and enabled to make its independent start upon the career of vitality, the primary germ-vesicle assumes its newly-acquired privilege of activity, and begins to multiply. First, two cells are seen lying together in the midst of the yolk-mass; then the two become four, and the four eight, and thus the process of subdivision goes on, until at length the yolk-substance is found to have been entirely absorbed, numerous vesicle-broods nourished through its material having assumed its place. But by this time the ovum has thrown out little rootlets, and, by their means, established a direct communication with the soft loose lining of the receptacle in which it lies, and so the further nutrition of the growing germ then goes on through them. Now, too, portions of the vesicle-broods commence to manifest a tendency to take upon themselves alterations that fit them for the construction of special organs. Rudiments of bone, cartilage, vessels, muscles and nerves appear, and these rudiments go on developing and arranging themselves, until, at last, when the young creature makes its *début* in the world, it possesses a frame-work fitted for all the manifold offices and duties it is destined to carry on.

It is matter of familiar knowledge that the fertilising vesicles and germ-vesicles in the higher species of the animal creation are not produced in the same individual zöon as they are in the great majority of the higher species of plants. The organs from which the two are evolved are, however, so nearly related to each other, in intimate nature, that the one may be readily mistaken for the other in the earliest period of their formation. Physiologists, indeed, now incline to the opinion that the fertilising vesicle is merely a germ-vesicle in a somewhat more exalted stage of development. Mr. Knight has shown that plants like the oak, that bear their male and female flowers on separate individuals, may be made to produce either at will, by regulating the supply of light and heat according to the end in view. If the heat be excessive as compared with light, male flowers only appear; but if the light be in excess, female flowers are produced. This at least is as it should be; and here physiological science is as poetically beautiful as it is physically just. As virile strength is fostered by warmth, the type of supreme grace in creation surely ought to be the especial charge of the luminiferous ether. The above-named experimenter also found that, whenever the eggs of birds are not allowed to be fertilised until immediately before they are laid, and, therefore, when their own intrinsic development has been carried to the highest possible pitch before renewed vivification of the germ-vesicle is effected, as many as six out of every seven of the birds subsequently hatched proved to be males. Quetelet believes that the relative ages of the male and female parent influence the sex of the offspring produced to a very considerable extent. Several very curious facts are on record in support of this view. M. Hofacker, for instance, has shown that, when the father is considerably younger than the mother, the proportion of female to male children is generally as ten to nine; but that when, on the other hand, the father is nine years older than the mother, the proportion of male offspring to female is as five to four, and, when eighteen years older, as two to one.

In a general way, more males of the human species are born into the world than females. If all Europe be included in the estimate, the proportion of male to female births is about as 106 to 100. Possibly, if Quetelet's views be based on truth, this preponderance on the side of the males may be due to the fact that in civilised communities men, from prudential and other motives, mostly marry women younger than themselves. There seems, however, to be a very good reason why this preponderance generally obtains in the existing state of affairs. Male life is considerably more obnoxious to accidental causes of arrest, in the earlier years of existence, than female. Three male children are born dead for every two female infants that make their *début* in the same undesirable state. During the first six months of life, five male children die for every four females. Male and female deaths then become pretty equal up to the thirteenth year. From the thirteenth to the eighteenth year of life, rather more females die than males. From the eighteenth to the twenty-eighth year, more males die than females. From the twenty-eighth to the fiftieth year, female life is again of somewhat less value than male existence; but, after that period, Darby and Joan walk to the grave pretty much hand in hand. The result of all this is, in the main, that at any given time more women are in existence than men, notwithstanding the fact that more males than females are born. There were half a million more females than males in the twenty-one millions of the people of Great Britain in 1851. There were then, therefore, forty-three females to every forty-one males. Many conceive that injurious indulgence in dissipated habits, on the part of men, during the early portion of adult life, accounts for the difference of the value of male and female life at that time. This, however, of course, in no way touches the question of the preponderance of still-born male children over still-born female. Here the result would rather seem to be a direct organic penalty paid by the gentlemen for the privileges of higher development, if such really be the fact. It is by no means an improbable thing that higher development would, in its early and helpless state, be more prone to be injuriously affected by accidental influences. If there be anything in the view that habits of dissipation raise the mortality among males during the first years of adult life, there is good ground for the hope that some progressive improvement is gradually taking place in this particular; for there was really a larger absolute preponderance of females over males, in Great Britain, in 1801 than in 1851. There were 518,000 more females than males in the ten millions and a half of 1801, and only 512,000 more females than males in the *twenty-one millions* of 1851. In 1801, there were twenty-two women to every twenty men. In 1851, twenty-one women to every twenty men. And it is a very remarkable fact that, during the intervening years, the former ratio steadily and progressively changed itself into the latter. In round numbers, there were twelve females to eleven males in 1811. There were fourteen females to thirteen males in 1821. Sixteen females to fifteen males in 1831; and nineteen females to eighteen males in 1841. This statistical result would almost seem to indicate that, between 1801 and 1851, men were learning to take more care of themselves.

One very curious and interesting consideration is involved in the near equality of the numbers of the two sexes, among the higher animals. This relation seems to be a direct adaptation to the habit of pairing, through which the care of both parents is secured to the offspring during its early helplessness. It has been stated that the higher and the more complex the development of the creature, the more dependent it is made to be upon the protection of the parent in early life. When the species is an herbivorous one, and finds abundance of food spread out for its use, day by day, over the verdant surface beneath its feet, parental care is easily given, and little more than maternal watching and nursing are required. Here, then, pairing is rarely or never found. But among carnivorous creatures, that procure their food by active pursuit, and among men, with whom forecast and provision take the place of instinct, the tendency of the sexes to pair is developed in a marked degree. With the predacious animals, a temporary association alone takes place, because the offspring is cast off from the nest or lair, so soon as its animal powers are sufficiently matured to enable it to cater for itself. The parents only cling together so long as one is required to hunt while the other is hatching or watching the young. With man, an enduring affection springs up, which makes the pairing an affair for life; and in the advanced stages of civilization this pairing is made the object of moral and religious sanction and of political enactment, in order that it may be so much the more binding and irrefragable in its continuance, and that thus parental care may be secured to the offspring until the powers of the mind, as well as the organisation of the body, are matured.

Data are probably at present wanting to determine the precise point in the scale of organic forms, at which the nearly equal production of the opposite sexes ceases to take place as a rule. But thus much at least is apparent,— nature's chief aim in arranging the economy of the lower species of life has been the ensuring a very rapid multiplication of individuals, whereas her main object in establishing the relations of the higher species has been the slow and cautious production of just so many individuals as can be comfortably lodged and maintained at the time. Hence the germ and fertilising vesicles of the lower species are thrown off from the parents very quickly, and are allowed to float or roll into communication at once; while those of the higher creatures get to be more carefully elaborated in separate organs, and are then only allowed to come into vitalising relations through a series of intervening arrangements. In the highest species myriads of both kinds of vesicles are formed to no purpose, and ultimately wasted; but then very complex and important results are worked out from every case of accomplished fertilisation. A single pair of fishes calls into being thousands of individuals like to themselves in one breeding season. Cats, pigs, and dogs, on the other hand, produce litters, comprising but a few young ones; and the yet higher mammals and man *as a rule* bring forth only one offspring at a birth. So, too, with these highly endowed creatures the length of time that is requisite for the perfection of each individual organization, before it is deemed ready to be cast off from the parental system, is of considerable extent. The education of the physical structure, so to speak, is more leisurely and carefully performed as the result proposed is of a wider and more extended nature.

The means that have been taken to ensure the vivification of the dormant germ-vesicles in the different races, are almost as varied as are the diverse forms of animal and vegetable life. With the simplest unicellular organisms, if, as is very probable, conjugation is a true reproductive operation, accidentally contiguous individuals assume the offices of germ and fertilising vesicles. In the more perfect plant both are contained in the same organ, and are so placed, that when the fertilising vesicles are scattered from their cases on the tips of the stamens, many must of necessity fall on the adhesive summit of the central column that surmounts the ovule cases. With many, both plants and animals, that dwell in water, the fertilising vesicles are furnished with the little self-acting propellers or oars, already described in detail, which row them off in pursuit of the germ-vesicles as soon as they are set free from their cases. Many of the so-called animalcules that enliven stagnant pools in the summer season are merely reproductive vesicles engaged in their fertilising work. With the higher animals far more complicated arrangements are made, and the affair is rendered one of instinct and will, and with man it is even a matter of judgment and reason. The irrational animals produce offspring whenever they can. Prudent and wise men do the same thing, whenever they can comfortably provide for them. In this sense many agencies, not elsewhere influential, come into operation to determine the rate at which the numbers of mankind multiply, and the abundance or scarcity of food may be said to limit human population, as it unquestionably does determine the numbers of the individuals of other races. But there is this difference in the two cases. The lower creatures, in circumstances of scarcity, are born to die off prematurely; whilst human beings under like circumstances, in the most perfect arrangements of rational life, are not called into existence at all. Early marriages shorten the interval that separates successive generations, and thus quicken the rate at which population increases. Late marriages, of course, operate in exactly the opposite way.

Renewed fertilisation of dormant germ-vesicles is generally employed as the means by which the type and essential character of a specific race is preserved unchanged. Thus any accidental variety of a plant may be propagated by cuttings, but not by its seeds. The seeds invariably produce a plant which bears only the original characteristics of the species from which the variety had sprung. As, then, amidst the higher animals there is no other method of multiplication, saving through the process of fertilising germ-vesicles, every individual starts from a condition which is *more or less closely* the standard type of the species. The standard, however, does vary within certain narrow limits, when long subjected to modifying external circumstances; and it is a notable fact that, with some species of animals, these induced modifications of structure are carried through successive generations, if the external conditions remain the same. In all probability, it is in this way that particular *races* originate. It is among the most hardy creatures; whether vegetable or animal—those, namely, that are able to exist in the greatest variety of external conditions without suffering injury,—that the greatest capacity for producing modified races is found. Thus man and the dog are able to live in every known part of the habitable world, and man and his canine attendant afford by far the largest list of varieties of race of all living creatures. *Apparently* the lion does not differ so much from the tiger as the Bosjeman of Africa differs from the dignified and accomplished philosopher, who sits on the benches of the Royal Society, or French academy, or as the King Charles's spaniel differs from the lordly St. Bernard mastiff, or the noble Newfoundland dog. Some very curious instances are known of the power climate, habits of life, and the nature of the food, possess in altering the characters of animals. Sir Charles Lyell mentions a case in which a pack of English greyhounds were taken out to hunt hares in one of the high table-land regions of Mexico. These dogs could not run far in the attenuated air into which they had been introduced without being forced to lie down and pant from exhaustion. But their whelps, produced in the elevated district, hunted as well in the rare atmosphere, and seemed to suffer as little fatigue as their parents had in English fields. Dr. Carpenter relates the fact that three or four lambs were accidentally produced in a flock in the state of Massachusetts, with legs so short that they could not leap fences. The owner of the lambs set them apart and bred from them, and thus called into existence what is known as the otter breed of sheep, a race that continues to exhibit the same desirable character. There is a tribe of dogs on the banks of the Magdalena which is much employed in hunting the white-tipped peccary. These dogs pursue a very peculiar line of tactics: they never follow any single animal, but keep the whole herd in check. They have been taught this trick in self-defence, for the peccaries invariably turn in mass upon any assailant who attacks one of their community. The young dogs of the Magdalena-breed start at once upon the approved plan of hunting when they are first taken into the woods. But if a strange dog, descended from another race, is introduced into the district, he at once rushes in upon the herd, and is surrounded and destroyed forthwith.

It is now the generally entertained opinion that the different races of mankind which are scattered over the earth, were originally called into existence in this way. When the world was thinly peopled, some few individuals, in whom certain strongly marked peculiarities chanced to exist, were possibly separated from their kind, and so bred from among themselves, until their characteristic qualities became deeply fixed in the organisation of their descendants. Races do not now originate in the same way, because it is no longer possible to isolate individuals possessing similar characters sufficiently to insure the result. Circumstances of an accidental nature do, nevertheless, affect the organisation of human beings in an inferior degree. What may have been mere matters of habit in parents often become inherent qualities in children. It will be at once seen how important this consideration is in affairs that relate to education. Long pursuit of vicious objects by parents tends to produce ingrained vice in children, and, conversely, ennobling thoughts and occupations lead to a higher organisation for the offspring. It has been remarked that the children of Blacks in the West Indies really lie instinctively and intuitively.

It is well ascertained that a strong and vigorous offspring results from parents of *different races.* The offspring of parents of different species (for such an offspring is an occasionally possible, though far from a general occurrence), on the other hand, are weak, and devoid of power to produce in their turn, even to one generation, and so die out at once. Unlike species produce weak and readily-exhausted offspring; but unlike varieties produce offspring of higher energies and higher powers of fertility. This is a very important arrangement. By the inability of hybrid offspring to multiply, the species is kept distinct and pure; but in consequence of the increased vigour of the children of mixed races, an impulse is given to the formation of endless varieties of character. One of nature's marked aims in the production of human beings undoubtedly is the securing of an endless diversity of power and form.

Growth is increase in the size of any body by the addition to itself of new substance. Organised structures, it has been seen, effect this growth by the formation of new broods of vesicles, and the attachment of these more or less firmly together into connected tissue, the material for the new constituent vesicles being taken from the food that is periodically admitted into the system. There are, however, two different kinds of growth effected in organised structures. The frames of organised bodies not only become larger as new material is added to them; but they also become *altered in type*, from time to time, by the founding and building up of new organs that had no existence in their earlier state. There is thus a growth of ripening development, as well as a growth of augmenting size. This is a very important distinction. Let it be supposed that a man, living in a barn composed of four bare walls, increased the space of his dwelling by pushing asunder the walls, and then building in new bricks at the extremities: he would thus have enlarged his barn. But suppose that, instead of doing this, he built partition walls across the interior of his barn, and placed a level floor over these, and then constructed new chambers above: he would then have converted his barn into a many-roomed house. He would, indeed, have altered its entire character, and have given it a new type. He would have *developed* a simple structure into a more complex one. Such is the difference between growth and development. All animals, saving the very rude cellular ones, undergo a development of this kind, as they grow. First their bodies assume some very simple rudimentary form; then this form is altered by the successive addition to it of the elements of new organs: as each fresh organ is added, a new character of life appears, and a new phase of being is entered on. Thus man himself, as has been seen, begins life as a simple vesicle. This vesicle adds brood after brood of vesicles to its progeny, enlarging the constituted mass thereby. In the mean time the vesicles get variously modified and arranged, and organ after organ is successively planned and framed. Within three or four weeks of the first division of the germ-vesicle, the foundations of the eyes, the limbs, and the spinal cord are laid; but the general outline of structure is only that of a lowly worm. If, at that time, the creature were separated from the fostering frame of the parent, and could maintain independent life, it would indeed be nothing more than a worm, however much it might grow. In two more weeks, however, such separation not taking place, traces of forming bone present themselves; a face is sketched out, and fingers may be traced. In two more weeks, a forehead, lungs, and ribs have been added. In another month, there is a rudimentary brain, and a two-sided heart. In two more months, the nails and the teeth bud; and in four beyond this, every organ is comprised in the scheme, that is necessary for the accomplishment of the aims of human life. Then the *growth of development* ceases; and from that time the growth of augmenting size alone goes on.

But although at a certain stage development ceases, so far as the entire frame of the creature, the collective *zöon*, is concerned, there is of necessity still an under-current of *zöoid* developments constantly taking place within that frame so long as its animated vitality endures. Every living vesicle is at first merely a little sphere of thin membrane, and a droplet of liquid contained within the film; and vesicular broods bearing this form are continually being produced by myriads, even after the zöon body has attained its full stature, to support the waste that animal activity entails upon organs that are its seat. All these myriads of vesicles, however, go through a process of maturation to fit them for their specific work; they are first germs, then infants, then adolescents, then adults, and finally worn-out seniles. Each has a little private history of its own, forming a miniature parallel to that of the system it helps to form. Some, as has been already explained in detail, ripen into fibres, others into consolidated osseous and cartilaginous masses, others into contractile muscles, and others into the tubes and chambers of the nervous apparatus. Not even the blood-corpuscles are exempted from this necessity. The flattened red discs which make the food of the muscular and nervous textures (*d* in *fig.* 15.) are themselves merely matured conditions of the colourless corpuscles that make the plastic fibrin (*c*, *fig.* 15.) The blood cells are primarily formed in the glands of the mesentery, through which the nutritious part of the digested food passes on its way into the general channel of the circulation. These glands are mainly composed of densely-packed clusters of vesicles. These vesicles multiply by germs very rapidly, and cast off brood after brood into the stream that is sweeping past them. Once immersed in the rich liquid of this stream, the abandoned vesicles find themselves literally in a place that is "flowing with milk and honey:" osmose comes into play; they freely drink in of the surrounding supply, fabricate fibrin out of one portion, and ripen their films, first into globular cells of mature dimensions, and ultimately into flattened discs, which are able to perfect the rich crimson compound that is the appointed pabulum for the highest efforts of animal life.

It sometimes happens—too often, indeed—in the zöon history, that derangements occur in the under-current of zöoid developments, in consequence of the body being exposed to physical influences that it was never intended it should have to meet. Vesicles that ought to grow and mature, either fail in their development, and decay prematurely, or they change development into too rapid multiplication, and the system is deluged with puny and unserviceable pigmies, in the place of being supplied with vigorous and perfected agents ready and able to perform its work. The derangement then expresses itself in various methods, which more or less involve the creature that is its seat in discomfort, or *disease*, as the state has appropriately been termed. It is in this way that, when the growth of the pale corpuscles of the blood into adult red discs is retarded or arrested, the blood is overloaded with plastic fibrin, in the place of its more nutritive crimson constituent, which it is the office of those discs to fabricate; and its channels get choked, and its circulating streams stagnated, by the adhesive burthen. Rheumatism and inflammation then ensue, and the muscular and nervous apparatus are weakened by starvation. When even the colourless corpuscles are incomplete, a low product is formed in the blood stream, in the place of the fibrin, which is altogether incapable of being vitalised, but which is, nevertheless, too abundant to be readily got rid of out of the system. This unvital product, then, does all sorts of mischief by clogging up important organs; and scrofula and consumption follow as the immediate consequence. When the vesicles do not ripen into the states appropriate to the several objects to which they are to be applied, but take it into their little cavities to waste upon multiplication the force that ought to be concentrated on maturation, brood after brood of a crude and immature progeny are called into being and loosely strung together.

The masses so formed then constitute what are technically known as malignant growths. These malignant growths are entirely composed of living and multiplying vesicles lying in the midst of molecules and fibres: they are illustrations of perverted cell-life. And inflammation, scrofula, and consumption are exhibitions of the results of degraded cell life.

But, to return to the growth of the zöon frames. Each organ, when its foundations have once been securely and completely laid, continues to enlarge on its own account, by adding new vesicles to its structure faster than the old ones can be destroyed; and this goes on up to the period of maturity of age. At this period the processes of cell production and cell destruction are evenly balanced, and the size of the general body neither increases nor diminishes; but after this period, vesicles are produced less rapidly than they are destroyed, in consequence of a sluggishness that is now creeping over the formative power. Vesicular vitality is flagging and verging towards exhaustion; and so waste takes the place of growth, and organic quiescence—death—advances with a rapid step to assert its rights.

Natural decay is simply the result of the final exhaustion of the productive vigour that was primarily communicated to the primeval germ-vesicle, when it was vivified at the dawn of zöon life.

In nearly all back-boned animals, which form a sort of privileged and noble order in the animate creation, the successive stages of ripening development are passed through privately and before the individual zöon enters upon life on its own account. The rudimentary and crude structure is kept shut up from public gaze, so to speak, until the artist has brought out all the details of his design. In one instance, however, this course of proceeding is departed from, and the commonly hidden operations of progressive development are carried on under the eye of observation. The frog swims about in the ditches as a tadpole before it takes upon itself the perfected type of the higher reptile form. But what happens in the frog's case as an exception, occurs constantly and as a general rule in a class of animated creatures that is lower than the vertebrated group in the scale of nature. Among the insect tribes, the process of successive development by progressive stages is obtrusively presented to notice, instead of being hidden away and concealed. What are familiarly termed the insect transformations are really steps in the process of organic development, and are therefore fraught with exceeding interest in this point of view.

All insects are limbless worms at one period of their observable and independent existence. It is only after they have lived for a certain length of time as independent creatures that limbs and other useful appendages get added to their frames. At first their entire organisation seems to be adapted solely to the office of feeding. The creature, indeed, is brought into independent life before its development is perfected, in order that it may cater for itself the food that is necessary to the completion of the process. The eggs are too small, and too many of them are laid by each producing parent, to allow of a sufficient store of nourishment being packed away therein for the purpose; and so, again, each female parent calls into being too many offspring to have the chance of nourishing them all from the juices of her own body. The process of development does not, however, go on smoothly and steadily in the insect tribes. It advances by fits and starts; and life is therefore seen, for longer or shorter periods, in phases of immaturity. Thus, beetles remain in a rudimentary worm state from three to six years before they assume their full glories; bees and wasps hasten through the same rudimentary condition in from five to fourteen days; grasshoppers and cockroaches get it over, like their higher congeners of the feathered tribes, before they crack their eggs.

During the progressive development of the insect frame, the organs of sense and motion, the *especially animal* portions of the structure, are seen to become more and more perfect. At the final change, the little clumsy knobs which the caterpillar is constrained to employ as feet are shaken off in favour of long, graceful, jointed limbs, which then appear; one or two pairs of beautiful nervous wings sprout from the shoulders; and the trailing digestive tube of a body gets packed away into a compact segment to which two other distinct pieces or compartments are added: the one, the thorax, serving for the support and attachment of the organs of motion; the other, the head, for the reception and accommodation of the organs of special sense. Most insects pass through an intermediate stage of existence, after leaving the worm state, before they put on their winged glories and assume their completed forms. This stage is nearly always one of deathlike repose, so far as all manifestations of animal life are concerned. It is indeed a temporary return to the embryonic condition in which the *growth of development* is carried on, instead of the *growth of enlargement.* During the continuance of this state, the creature is altogether unequal to the task of taking any care of itself. It ceases to swallow food, and remains motionless, encased in a dry mummy-like skin. All this time the developing activities are at work, although the growing activities are suspended. Grasshoppers and locusts continue to be active while in this intermediate stage. In these tribes, however, the preliminary worm-like condition is spent in inactivity, as has been already stated; and hence, in the transition state, the creature has to hang for a time between the worm and the fly state, eating voraciously to acquire material for the final development, and then passing through it without any second embryonic pause. Other insects, like the beetles and butterflies, do the feeding work in their worm-state, lay up a store of fat for the developing powers to make use of, and then retire into the chrysalis skin, as if into a second egg-shell, to await the change. The beetles and the butterflies hasten their *growth* first, and then mature their *development;* the grasshoppers and the allied tribes quicken their *development,* and then look after their *growth.* Growth and development are thus in this class of living creatures seen, as it were, weighed and balanced against each other; and whatever force is added to one scale seems as if of necessity withdrawn from the other. The curious processes of insect transformation are exquisite studies, in which nature appears to have presented certain grand outlines of her organising designs for the contemplation of observant man.

Bees are excluded from their eggs in even an earlier stage of their development than other insects. When they are hatched, they are small grubs without the slightest trace of feet of any kind, and they are literally as helpless as the new-born infants of the human species, They can do nothing whatever for themselves. Their food is provided for them, and almost put into their mouths by a band of assiduous nurses, which consequently form a most important portion of the bee community. These nurses deposit the food from time to time in such a way that the little grub nursling is induced to wriggle itself round in its cell, getting nearer and nearer to the mouth. After a few days of this kind of cramming, however, the judicious nurse stops the supplies, and fits a waxen lid close to the chamber containing its charge. The abandoned nursling then contentedly winds itself up in a silken bag, and remains quiet for about three days. At the end of that time, it wakes up, eats its way through both silken bag and waxen lid, and then marches out of its prison a perfect full-grown bee. It takes altogether twenty days to turn out a mature bee from the time the egg is fresh laid in the waxen cell by the parent insect.

The bees that come out of their cells on the twentieth day, and that form the great bulk of the community of the hive, are not, however, in one sense, perfect insects. They none of them contain either germ-vesicles or fertilising vesicles within their frames, and are therefore unable to multiply their kind. They are what is termed neuters, and have simply the charge of the domestic economy of the hive. In each community, a single individual is kept to perform the work of reproduction. This productive individual comes out from a larger cell than the rest, and makes her appearance on the sixteenth, instead of on the twentieth day. The grub from which she is produced is fed upon a stimulating jelly, provided and carefully kept for its exclusive use. Several large cells are prepared, in the first instance; and the grubs in each of these are served in the same royal way, in order that there may be no risk of the process resulting in failure. The first fertile insect that appears from these large cells then proceeds to make good use of her privilege of primogeniture. She immediately tears down the walls of all the other large cells, and executes summary vengeance upon their inmates, with her sting. It is now generally believed that the neuter bees are all females arrested in an early stage of development, and that the fertile bees are neuters whose development had been fostered and quickened by means of highly-stimulating food. The neuters, no doubt, are able to make productive females at pleasure. Whenever a hive has experienced, by some unfortunate chance, the loss of its common mother, the workers proceed forthwith to tear down the walls of a few of the ordinary six-sided cells, drag out the contained grubs, and then erect, in place of the demolished chambers, a series of upright cylindrical ones. In these, some of the ordinary eggs are stored away; and the grubs hatched from them are then fed into fully-developed productive insects.

Each maternal bee deposits about twelve thousand eggs. This number is generally disposed of in a couple of months, one being placed in every empty cell of the waxen comb. The first ten thousand eggs laid all hatch into neuter grubs. The remaining two thousand are destined for a different use. They produce grubs that do not assume the winged state until the twenty-fourth day after the deposit of the egg. These insects are unlike the ordinary workers when they come forth from their nurseries They have short, thick, clumsy bodies, entirely covered with hair; they have also small tongues and jaws, and have no baskets on their thighs, or stings in their tails. They are, in fact, lazy drones, unfitted for any useful work, and unable to contribute in any way to the economy of the hive. They have developed within them, however, the fertilising vesicles of the species, and are, in fact, the males of the community. On sunny days these gay sparks indulge in long flights in the clear air; and the young mother of the future brood accompanies them on some of these pleasure excursions. Their unproductive presence in the hive is, however, merely tolerated by the industrious workers, from the first, as a necessary evil. About the end of July, the prudent neuters calculate that they can be of no further use in the well-ordered community; and so they then drive them to the bottom of their dwelling, and dispose of them with their stings.

With ants the bulk of the community consists of neuters, exactly as among the bees; but these neuters are wingless. In the advanced hatching season, a few individuals appear with wings on their shoulders. These are the males and females of the race. They leave the nest directly they emerge from the grub condition. The males never return. Some of the females found new settlements in other places; but the rest come back to the original nest. In either case, their first proceeding on settling down is to strip off their own wings, as if to avoid all further temptation to follow a roving life. They then betake themselves in earnest to the task of depositing their eggs, but perish on the approach of winter. Only the neuters survive the cold.

The phenomena observed among the social insects seem, then, to confirm the view that difference of sex in the animal kingdom is merely difference in the extent of individual development; and the fact that the last eggs laid by the female bee produce only males, when hatched, favours the notion alluded to above, that the males are the higher development. The lives of the social insects are full of most interesting physiological suggestions. Thus, the analogy between their condition of existence and that of the perennial plant is very surprisingly and strikingly marked. Trees are vegetable individuals, living in a state of close association together in one system.

Each leaf-bud is as independent in its mere organic nature as the several working bees in a hive are, and it is neuter too, possessing in its own framework neither germ vesicles nor fertilising vesicles. After a certain number of leaf buds have been produced upon a tree, others are, however, formed that contain both germ and fertilising vesicles, and that ripen into flowers. When the germ-vesicles of these flowers are matured and fertilised, the fertilising organs wither away, and the perfected seeds are flung off from the branches where they have been produced, to carry the race to some new place suited to its reception. The entire process of fruiting and seeding is indeed a compensation for the stationary character of vegetable life. It is a provision for the wide diffusion of the species of the fixed individual over the surface of the earth. But so also is it in the economy of the social ants. The nest consists of animated individuals living together in a system of close association, and possessing very limited powers of rambling. These individuals are neuters, and quite unable to multiply their kind; but after a certain number of them have been produced, other individuals are formed, that ripen into males and females, and that are then flung off from the community, like so many winged and animated seeds, commissioned to the task of replenishing the earth with their own specific forms. Here, too, it is seen, that the individuals containing the fertilising vesicles perish so soon as their offices are fulfilled; while those containing the germ-vesicles have a longer life accorded them, that they may deposit their germs in appropriate stations. The ruthless habits of the bees, in relation to their treatment of the drones, are, no doubt, in accordance with the strict economy of life. With the bees, as with all other animals, the number of individuals that can be supported in any given locality depends upon the quantity of available food present. But this varies exceedingly with the season. Some seasons afford nourishment for millions more of individuals than others. This is strikingly illustrated in the case of the fruit-feeding wasps. These, in common with other races of social insects, have been made so productive, that very few fertile individuals suffice to keep up an enormous stock of the species. A single wasp foundress produces a triple generation of thirty thousand descendants in the course of a single season. Therefore it is, that the air becomes filled with these yellow barbed forms so soon as the garden walls are covered with luscious fruit, although there were only a few stragglers in existence but a short time before. The bees do not trust to the chance of the season for their supply of food. They lay in a certain store for future use. But they also, with becoming prudence, take it upon themselves to husband the resources they have scraped together. Hence they will have nothing more to do with the drones than is absolutely essential for the continuance of their race, and get rid of the burthen of unproductive consumers as soon as they can. And hence also, if at any time two productive females march out of their waxen cells at the same instant, the bee neuters stand round as unconcerned spectators, while the viragos by single combat decide the weighty question of who is to be the future mother of the hive, quite satisfied so long as one individual with her twelve thousand-fold egg fecundity is left to them.

The organic economy of the social insects presents one point of marked distinction from that of the perennial tree, notwithstanding the strong general resemblance that has been pointed out. The leaf buds of a tree go on multiplying, apparently without limit, although neither germ nor fertilising vesicles are included within their frames. The neuters of the social insects, which have been compared with leaf buds of trees, on the other hand, possess no reproductive capacities whatever. They can do nothing but keep their own organs in working condition for a certain length of time; and then their vesicular or organic vitality is exhausted, and they disappear entirely from the scene. Nature, however, has not allowed the strength of this instructive analogy to fail for the want of a single link; the chain of connection is really complete; but it was reserved for the sagacity of Professor Owen to discover the fact, and to bring it prominently forward into the light.

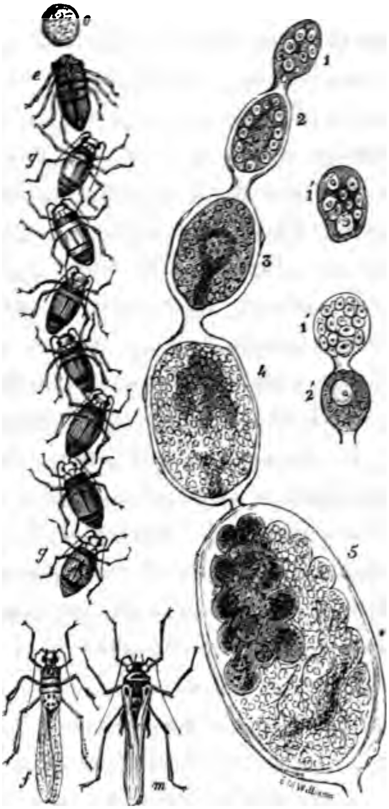
Nearly every kind of vegetable structure suffers from the ravages of a tribe of insects of a very low organisation, but possessed, nevertheless, of very considerable powers for mischief. These little destructives are known as the blight insects. They are all of inconspicuous forms and diminutive statures; but they make up for the smallness of their size by the greatness of their numbers. Some of them look like minute green scales sticking over the surfaces they infest. Others present no other trace of their presence than patches of frothy substance in which they have enveloped themselves, the froth being formed in the viscid juices they have extracted from beneath their feet. They are all of them destitute of jaws, but have, in their place, long rigid pipes, which they pierce into the vegetable structures that constitute their food; and through these they imbibe the elaborated juices, until the living tissues are exhausted by the drain.

One of the best known of the blighting parasites is the aphis of the rose. There are few persons who have not, at some chance time or other, been annoyed by seeing the stalk of one of their favourite flowers of June completely ensheathed by a covering of little green viscid insects. Each of these unwelcome visitants of the rose possesses a round, plump body, supported on six slender legs, and furnished with a pair of respectable feelers projecting out in front, and two oddly-shaped spikes pro-

flocks, who have magnificent wings stuck rigidly and proudly up from their backs. Now these winged aphides are, like the winged ants, the males and females of the species. The individuals that form the great bulk of the colonies, and that are wingless, are not, however, neuters, as is the case with the ants; they are all females. No gentlemen ever make their appearance among them until quite the end of the summer. Yet those females go on producing generation after generation of forms of like organisation to themselves. This is the surprising peculiarity in the history under consideration. The fertilised germ-vesicle of the aphis is deposited as an ovum by one of the winged females at the close of the summer, in the snug nook formed by the union of a rose-leaf with its stem. This egg is hatched by the returning warmth of spring; and out of it there then comes a wingless, six-footed grub, which is not only a grub, but also a female grub, and a wondrously productive one to boot. For after a few days she gives birth to eight wingless, six-footed creatures like to herself. Each of these is also a productive female, as well as a grub, and, in her turn, soon gives birth to another generation of eight forlorn grubs, who thus, strange to say, are not only fatherless, but really must have been fatherless, and have been in existence, in a physiological sense, even before their mother was born. The only paternal influence they had received must have been handed down to them through the primeval egg that produced their own grand-parent. This singular process of multiplication goes on, generation after generation, in favourable seasons up to the tenth or eleventh successive aphis brood, so that, if the ranks of the thriving race were not thinned by the attacks of depredators, the descendants of a single first parent might number within one season ten thousand million of millions, and this too without any renewal of the fertilising influence. Even taking into account the loss suffered in consequence of the wars that are incessantly waged against their race, the plant-lice still are, upon the whole, the most destructive pests with which the labours of agriculturists and horticulturists have to contend. The presence or absence of one species alone, which chances to have a decided fancy for the hop plant, makes a difference of nearly half a million of money in the yearly revenue of Great Britain. Hops pay a yearly duty to the government of about 500,000*l.* in favourable seasons; but when the hop aphis attacks the growing plant, this branch of the revenue occasionally sinks to 15,000*l.*

This extraordinary production of successive generations of distinct living creatures from one maternal parent, without any renewal of fertilisation for any of the broods, has been designated "Parthenogenesis" (*Virgin-birth*) by Professor Owen. The facts of the case are diagrammatically represented to the eye by the following figure (*fig.* 39.). *o* is the egg that is deposited in the autumn on the stalk of the rose leaf; *e* is the grub that is hatched from the egg in the spring; *g* to *g* are seven successive generations of wingless aphides that are subsequently produced. But it must be remembered that each of these is the representative of numbers that increase in an enormous ratio. The first *g* is the representative of 8; the second of 8 × 8 = 64; the third of 8 × 8 × 8 = 512; and the seventh of 8 × 8 × 8 × 8 × 8 × 8 × 8. *f* and *m* are the representatives of the ninth generation, which is produced last in the season; and these are winged females and males. The chain of objects from 1 to 5 illustrates the manner in which each aphis brood is produced. 1 and 2 are the uppermost chambers in a sort of ovarian

Fig. 39.



tube. Of these 1 is filled with a cluster of germ vesicles, as seen more distinctly at 1′. One of these vesicles descends into 2 (shown at 2′ just arrived), and there begins to produce vesicular broods by its own multiplication and subdivision. From 2 it is passed on into chambers 3, 4, and 5, gradually enlarging and becoming of more complex organisation as it goes, until at length it assumes the complete grub form, *g*. It is towards the end of the summer season, when the vesicular productiveness is probably near to exhaustion, that a special provision is made for the perpetuation of the race, which would infallibly be destroyed by the first accession of severe cold, apart from the necessary result of the exhaustion. The new brood is then converted into a final generation of males and females, which are both furnished with wings. Both germ and fertilising vesicles are developed. The germ vesicles are fertilised, and are carried away by the wings attached to the body of the female, to be deposited as eggs in places suitable for development upon the return of the genial season. In this way, therefore, the analogy with the operations in the vegetable kingdom is made complete. Each of the grubs of the intermediate broods is really an aphis bud, rather than a perfect female, and is protruded from the parental body as leaf buds are pushed forth from the stems of plants. The early generations of the aphis are *budded* rather than born, each bud separating from the interior masses of the producing structure, and finding its way into external space through a channel left for the purpose in the organisation. The term *virgin-birth* might perhaps be advantageously exchanged for *animal gemmation* (animal budding). In growing trees young buds, that are the offspring of some primeval germ-fertilisation, produce successive generations of bodies like to themselves, without the intervention of any fresh fertilising influence; but after a time stamen and ovule-bearing flowers are formed, instead of more generations of ordinary branch-making buds. Then the matured seeds separate from the parent structure and fall to the ground, or are borne away to distant regions by wings (in this case the wings of the wind), in order that the race may be maintained in dormant existence through the winter's cold, and be subsequently again recalled into activity far and wide. But the wingless grubs of the aphis are scarcely more locomotive than the leaf buds of a tree. So long as there remains the smallest drop of sap in the stalk or leaf on which they chance to be, they stick to their positions, unless forcibly driven from them. It only needs that a colony of them should be conceived to be bound together by a common investment of skin, as they lie in their lazy ranks, and that the new buds should continue to shoot from this connected mass, without being separated from it, until the final generation of winged females and males are produced; and there is then before the imagination a picture of an aphis stem pushing forth its aphis buds, and at the appropriate season blossoming its special reproductive apparatus of aphis flowers. The wingless grubs are to the aphis colony precisely what the leaf buds are to the perennial shrub or tree; and the winged and perfected insects are what the flowers and seeds are to the perennial tree. Each bears the same relation to, and performs the same office in, the general economy of the organisation to which it belongs, and on this account becomes as pleasant a spectacle to the physiological eye as it is a disagreeable one to the horticultural organ of vision. Blight insects were not made suctivorous and sedentary to plague farmers and gardeners. They have some definite and important position in the scheme of nature, to which this result is merely accidental and secondary. What this position is, has not yet been fully ascertained; but pending its discovery, these sedate little topers have at least improvised a Lecture on the Philosophy of Reproduction, whose import, thanks to the ready attention and sagacious comprehension of the Hunterian Professor, has not been altogether lost to the science of man.

THE END.

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